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A TRANSPORTATION CONTROL STRATEGY FOR THE PHOENIX-TUCSON AIR QUALITY AREA

Fred Winkler

TRW Transportation and Environmental Operations

Prepared for:

Environmental Protection Agency

December 1972

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Vehicle Mix - distribution of motor vehicle population by age group.
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PREFACE

Presented herein is a report which discusses the formulation of a transportation control strategy for meeting the promulgated air quality standards in the Phoenix-Tucson area. Development of this plan was in full recognition that exhaust emissions from automobiles presently constitute a major source of the air pollution problem. The approach taken in developing a viable plan consisted of identifying those transportation control measures which would have the widest possible public acceptance and yet in the limit meet the imposed standards. Hopefully, this report and the proposed transportation control strategy achieve both objectives.

ACKNOWLEDGEMENT

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The contributions of Messrs. Arthur A. Aymar and Bruce Scott of the Arizona State Department of Health, and Mr. Robert Taylor of the Maricopa County Bureau of Air Pollution Control were of particular significance.

Mr. Fred Winkler of the Land Use Planning Branch served as Project Officer. Work under the contract was monitored by Mr. Robert Clark of Land Use Planning, and Mr. Ron Mueller of Region IX.

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SUMMARY

This report, prepared by TRW for the Environmental Protection Agency, deals with the formulation of viable transportation control strategy for meeting the promulgated national air ambient standards in the Phoenix-Tucson area. Specifically, this report is concerned with:

- The identification of the most promising transportation control measures to achieve the required air quality standards.
- The prediction of emission reductions and air quality impact anticipated from each of the control measures and strategies considered.
- The assessment and documentation of those political, institutional, legal, and socio-economic obstacles that can be expected in the implementation process.
- The formulation of a timetable of key checkpoints to be used by the Environmental Protection Agency in monitoring implementation progress.

The development of a comprehensive transportation control strategy constitutes a major step towards achieving the desired air quality standards in the Phoenix-Tucson area. Unfortunately, existing Set II pollutant concentration data for Tucson and other areas outside Phoenix is not sufficient for use as a basis for forecasting air quality in those areas. For this reason, control measures included in this study could not be evaluated for use specifically in Tucson. However, it is recommended that the general results of this study be used as much as possible in current and future Tucson air quality programs.

The proposed transportation control strategy is specifically designed to meet the hydrocarbon (HC) and primary oxidant (O_x) standards by 1975, and the carbon monoxide (CO) standard by 1977. The strategy does not directly address itself to achieving the nitrogen dioxide (NO_2) standard The Arizona State Implementation Plan [19] was reviewed and the 1969 emissions inventory and air quality data from this plan were used as the baseline for making projections. Estimates of future air quality were made based on current stationary source control policies and forecasted growth. The results of this study must be viewed within this context.

CONTROL STRATEGY SPECIFICATION

A wide variety of promising control measures were examined during the course of this investigation. Selection of the "best" measure for incorporation into the proposed transportation control strategy was based, in part, on two general criteria:

(1) Maximum cost effectiveness with proven reliability

(2) Widest possible public acceptance with minimum socio-economic impact.

The proposed transportation control strategy developed for the Phoenix area consists of two distinct phases. Phase I is designed to accomplish substantial improvements in air quality for the 1975 through 1977 period. Based on analysis of current data (1969), however, additional controls may be necessary. Consequently, a Phase II program has been formulated in order to insure compliance with the standards. The need for implementing Phase II should be based on the results obtained from Phase I. The measures associated with both phases of the proposed transportation control strategy are listed below:

Phase I

- Air quality surveillance system
- Mandatory vehicle inspection/maintenance for all vehicles
- Retrofit emission control for all pre-1968 vehicles
- Evaporative emission control.

Phase II (if necessary)

- Vehicle exchange program
- Limited second vehicle registration

A brief description of each measure is presented in the following. A more definitive description of these measures appears in the next section.

Air Quality Surveillance System

The surveillance system proposed in this strategy uses the existing system and the system recommended by the Arizona State Implementation Plan as a foundation for developing the capability for monitoring Set II pollutants in the Phoenix-Tucson problem area. The recommendations in this strategy consist mostly of expanding the use of CO and O_x monitors through the metropolitan area to provide for reasonable accuracy in evaluating peaks and trends in air quality and in assessing the effectiveness of the implementation plan. It has been found that sites used or proposed prior to this strategy can generally be used and that they provide an effective distribution of monitors. The approximate cost of equipment for the system proposed in this strategy is $24,000 and $33,000. In addition, the MCHD mobile lab is regarded as a highly useful means of determining the spread of pollutant concentration and of identifying the need for longer-term monitoring and source control.

Mandatory Vehicle Inspection/Maintenance

One of the key components of the transportation control strategy involves a mandatory program of vehicle inspection/maintenance. Such a program will yield not only moderate emission reductions from the present vehicle fleet, but will also insure the proper operation of advanced control systems as they are introduced into the automobile population. It is this second factor that, in the long run, will have the largest impact on air quality.

Current studies indicate that the most cost-effective program involves a yearly exhaust emission inspection under load, followed as necessary by fuel ratio, ignition system (misfire), air cleaner, and PCV valve. Pass/fail exhaust emission criteria should be established to obtain the necessary emission reductions. A rejection rate of 30 to 40 percent may be required for the first year. The program should include a certification of service garages involved to insure reliable maintenance repair. Any retest of emissions after maintenance should be made optional. Estimates of potential emission reductions for the total population are 12 percent for hydrocarbons, 10 percent for carbon monoxide, and 0 percent for oxides of nitrogen. These reductions can be achieved for an annual cost of between $5 and $15 per car.

Retrofit Emission Control

The second recommended control measure consists of retrofitting the pre-1968 portion of the vehicle population. Basically, there are two retrofit approaches that are suitable for use in the Phoenix metropolitan area. The first one -- Vacuum Spark Advance Disconnect (VSAD) -- is particularly attractive for use on older vehicles in terms of potential emission reduction, cost, reliability and ease of implementation. Costs, including labor and with a simple override mechanism, should be from $15 to $30. Some deterioration in fuel economy and driveability will occur on the average. Overheating may be a serious problem, especially during hot weather.

The other retrofit approach -- Lean Idle Setting (LIS) -- has good possibilities except for a high probability of owner or mechanic tampering. This procedure involves the additional leaning out of the air/fuel ratio beyond the manufacturer's specification. The cost per adjustment should be nominal -- $3 to $6 -- and fuel economy should improve slightly on the average. This modification is theoretically simple, but present mechanic ability and instrumentation limitations indicate the need for substantial improvement.

The combined emission reduction potential for both retrofit devices was computed as 25 percent for HC, 9 percent for CO, and 23 percent for NO_x. Again, this is consistent with current EPA estimates. In order to insure proper operation of these two systems, especially LIS, it is suggested that both be incorporated into the annual inspection program.

Evaporative Emission Control

The third element of the control strategy calls for the control of evaporative losses. Vehicle operation (carburetor and gas tank) and gasoline marketing (gas tank and storage tank filling) represent the two main sources of hydrocarbon evaporative losses in the Phoenix area. For controlling losses from the inuse fleet (pre-1971), it is recommended that the Reid vapor pressure (RVP) for all gasoline marketed in the Phoenix area be controlled seasonally. This should yield more than a 30 percent reduction in vehicle operating losses [23] with moderate impact (approximately 1-2¢ per gallon) on overall marketing operations [7,32]. Some driveability problems may occur (during start-up), although they should be of a minimal nature [23]. The photochemical reactivity of the evaporated hydrocarbons may be altered by changing the RVP, but it appears that the change will be small [23, 34, 37].

Several methods are available for controlling evaporative losses from gasoline marketing. These include a totally enclosed transfer system used with either an adsorber, condenser or vapor return system. Approximately 70 percent of the vehicles on the road (mostly domestic) can be serviced from one adaptive system. The average costs of equipping service stations in the Phoenix area with evaporative recovery systems should run about $2000 per station.

Vehicle Exchange Program

All things considered, older vehicles (pre-1968) emit higher emissions per mile than do later model automobiles. The Vehicle Exchange Program is designed to take advantage of this situation by limiting the importation of pre-1968 vehicles and by replacing some of the older vintage cars with newer, lower emitting vehicles. Considerations should be given to limiting out-of-state vehicle registration for pre-1968 cars after 31 December 1973. This would have the effect of reducing the aggregate exhaust emissions by about three (3) percent.

Coupled with this would be a program to replace a segment of the older in-use cars with newer state and local government vehicles. One phase of this program would be to increase the rate of turnover of state owned vehicles to around 50 percent per year. Based on the current size of the state fleet, approximately 5000 cars would be available for exchange with pre-1968 vehicles on a yearly basis.

Criteria for exchange would have to be developed, based upon income considerations, in order to maximize program effectiveness. This combined program would be of short-term value. since by 1980 only about three (3) percent of the vehicle population will consist of pre-1968 automobiles. The administrative costs of this program should only add a small increment to ongoing registration costs. However, the costs associated with exchanging these vehicles may be on the order of several million additional dollars annually.

The net effect of both programs in terms of emission reduction potential should be around six (6) percent.

Limited Second Vehicle Registration

A preliminary assessment of the impact of the foregoing measures on air quality indicates the potential need for additional vehicle control. Specifically, it appears that up to thirty (30) percent reduction in vehicle miles traveled (VMT) -- implying a need for an additional thirty percent air quality improvement -- may be required to achieve the national standards. The uncertainty in this estimate is closely related to the uncertainty in the baseline emissions data and limitations in the current methods used for predicting future air quality.

One approach for insuring such a reduction in VMT is by restricting the use of second and third family cars. This could be accomplished through the registration process, but the details and implications of a specific program would have to be very carefully assessed in terms of the political, institutional, legal and socio-economic impact on the Phoenix area. One positive benefit of such a program would be more efficient use of the family's primary vehicle which in turn would tend to encourage car pooling and some additional use of the mass transit system. Variances on this restriction could be granted if the vehicle were converted over to operate on gaseous fuels.

Preliminary estimates of the carrying capacity of the Phoenix transportation system indicate sufficient flexibility to accommodate a substantial portion of the affected motoring public. It should be re-emphasized, however, that vehicle use restriction control measures should not be implemented until further analysis (using refined air quality data and improved forecasting techniques) can demonstrate the inherent need.

PREDICTED AIR QUALITY

The impact of each of these control measures, taken individually and collectively, on future air quality has been made for the 1975 through 1980 period.* The reference air quality data used in conducting this assessment comes from the Arizona State Implementation Plan. Forecasts of air quality indicate that some form of additional controls will be needed to meet the carbon monoxide, photochemical oxidants, and oxides of nitrogen standards. Specifically, a 50 percent reduction in CO and a 25 percent reduction in O_x above that achieved from ongoing and/or planned programswill be necessary. Estimates of required NO_2 reductions are not given, since the transportation plan has not been designed to directly control NO_2.

Based on the above, control of CO (8 Hr Max) becomes the constraining element of the control plan. That is, the application of a control plan designed to achieve the standard for CO (8 Hr Max) may yield air quality concentrations for the other Set II pollutants substantially below the required levels. This situation generally results in the expenditure of excessive resources.

Application of the proposed control strategy on forecasted Set II concentration levels for the Phoenix area yielded the following results:

- o Hydrocarbon levels (6-9 AM Max) are well below the standard by 1975
- o Carbon Monoxide levels (1 Hr Max) are well below the standard by 1977
- o Carbon Monoxide levels (8 Hr Max) are within the standard by 1977

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*Estimates of future air quality were made using the computer simulation model described in Appendix G.

- o Nitrogen Dioxide levels (annual) are substantially above the standard through 1980
- o Photochemical oxidants levels (1 Hr Max) are within the standard by 1975

The variances in predicted air quality for CO and O_x vis-a-vis the standards are well within the limits of uncertainty associated with the data base and methods of forecasting.

Obstacle Evaluation

The proposed transportation control strategy has been designed to yield maximum benefits while minimizing the number of potential implementation obstacles. The general philosophy adopted in developing the plan was to enlarge or accelerate the existing programs as much as feasible, rather than specify new ones. Consequently, the plan begins with air quality management procedures which have already been legislated, instituted, and generally accepted, and attempts to provide a smooth administrative progression to attainment of national ambient standards by Federal deadlines.

No major problems are anticipated for implementation of the vehicle inspection/maintenance program, vehicle retrofit program and gasoline evaporative emission control program, since these programs are either ongoing or have a high probability of social and political acceptance, as demonstrated, for example, in the Phoenix Attitude Survey.* However, some opposition to evaporative emission control should be expected from the oil companies.

The final two control programs, vehicle exchange and limited registration, are obviously the most controversial and, therefore, are subject to the most discussion and debate. Statements of concern can be expected from almost every segment of the community and in all likelihood would result in a number of obstacles which could delay the implementation of this particular program. Again, the importance of determining the actual need for these two programs cannot be over emphasized.

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*See Appendix H.

The Air Quality Surveillance Program, although not an emission reduction measure, represents an integral element of the control strategy. The present surveillance system should be expanded in order to provide comprehensive air quality data for the Phoenix-Tucson area. The main obstacle to be overcome is the acquisition of sufficient resources to fund the expanded program. EPA grant assistance is vital to this program in both Maricopa and Pima counties. The county health departments should continue their leadership in the expanded program.

IMPLEMENTATION TIMETABLE

Table 1 presents an overview of the timetable developed for implementing the proposed transportation control strategy. This schedule can be used by the Environmental Protection Agency to monitor the progress of the various proposed programs. This progress will depend heavily on the availability of EPA funds.

Time delays due to lawsuits and other overt actions have not been factored into the schedule since it is impossible to anticipate and characterize the impact of these events. It is clear, however, that some delays will occur due to uncontrollable events such as labor disputes and political/legislative entanglements. Some "pad" has been added to the basic schedule to cover such contingencies; however, it may be insufficient to overcome this class of obstacles.

The schedule is keyed to the early deployment of the inspection/maintenance and air quality surveillance programs. Both programs, taken collectively, form the cornerstone of the entire plan and provide the basis and justification for the remaining programs. Consequently, a great deal of attention should be placed on guaranteeing their proper implementation. Both programs should be fully operational, at the county level, by the middle of 1974. This would actually permit nearly one year to determine the need for the last two control measures. If a two-year variance (1975 to 1977) is granted for achieving the photochemical oxidant levels, as recommended by this study, the timetable for the entire program can be relaxed. It appears that the schedule specified by the State for deploying the inspection/maintenance program must be accelerated to be consistent with the recommended timetable.

Table 1. SUMMARY OF PROPOSED IMPLEMENTATION SCHEDULE

Element	Important Dates
Development of proposed transportation control strategy.	Completed 31 December 1972.
Recommended additions to air quality surveillance system.	Installed by August 1974.
Phase I Programs:	
Traffic system modifications.	Ongoing through 1977.
Inspection/Maintenance Program.	Mandatory inspections in Maricopa and Pima completed July 1974.
Retrofit of pre-1968 vehicles.	Completed July 1974.
Gasoline evaporative loss control.	Effective by 1 January 1975.
Phase II Programs (if necessary):	
Vehicle exchange.	Effective 1 January 1975[a].
Limited vehicle registration.	Effective 1 January 1975[a].

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[a] Date could be extended two years if state is granted variance for meeting O_x standard.

CONCLUSIONS AND RECOMMENDATIONS

Presented below are the major conclusions and recommendations that have emerged as a result of this study. The conclusions are based for the most part on the results developed under current study groundrules and assumptions. The recommendations have been designed to expand the scope and breadth of the study as well as to insure the proper implementation of the proposed transportation control strategy.

CONCLUSIONS

- Forecasts of air quality based on existing and/or planned programs indicate the need for additional control to meet the national standards for all Set II pollutants. These estimates of future air quality for the period of 1975 through 1980 could have a variance of at least ± 30 percent.

- Based on the currently available air quality data and approved analytical methodology, the proposed transportation control strategy will achieve the air quality standards for hydrocarbons and photochemical oxidants by 1975 and for carbon monoxide by 1977.
- The control measures selected for incorporation into the transportation plan are all technically feasible and economically viable. However, large uncertainties exist in terms of the political implications of Phase II Programs. (Vehicle exchange and second car use restriction.)

- Results from the public survey reveal that inspection/maintenance is the most attractive alternative whereas second car use restriction appears the least acceptable measure.

- Conversion of older cars (pre-1971) to liquid petroleum gas appears politically and economically unattractive.
- Direct incentives to encourage car pooling and new freeway construction to reduce stop-and-go traffic offer only marginal gains.
- Measures employing various rationing concepts are particularly unattractive due to their administrative and socio-political complications.
- Stationary sources will contribute the major portion of NO_2 emissions by 1975. The impact of this shift on the formulation of photochemical oxidants is presently unknown.
- Existing transit service in the Phoenix area is well run and provides good coverage. The area's highly dispersed population patterns, however, limit the effectiveness of potential rapid transit systems.
- The application of the proposed plan on a state wide basis should help achieve the national standards for the Tucson-Pima County region.
- The estimated cost for the Phase I Program is approximately $20 to $30 per car per year. The potential cost for Phase II may run $5 to $10 per car per year. Funding from both EPA and the state will be essential to insure the effectiveness of the strategy.

RECOMMENDATIONS

- The proposed transportation control strategy should be considered for statewide application.
- The Arizona State Department of Health should oversee and manage the transportation control strategy. Co-operation from local agencies is necessary for monitoring and enforcing the strategy.

- The state should request from the EPA a two year extension to 1977 for reaching the oxidant standard in Phoenix. This would allow sufficient time to insure the maximum effect of Phase I of the proposed strategy and may obviate the necessity for employing the less attractive Phase II measures.

- Forecasts of future air quality should be made using an updated emissions inventory and air quality data base (1971). The effectiveness of each control measure should be assessed against these forecasts.

- The Phase I control measures should be implemented during 1974 in order to determine the actual need (both analytically and empirically) for imposing the Phase II measures.

- The current air quality surveillance network in the Phoenix area should be expanded to provide more complete coverage.

- Consistent air quality data should be collected for the Tucson-Pima County area in order to determine the impact of the state wide control strategy on local air quality.

- The role of stationary sources in defining air quality should be carefully examined since it effects the necessity and effectiveness of the proposed strategy.

- The ongoing vehicle inspection/maintenance program should be accelerated. The program should contain the capability for assessing both retrofit and advance emissions control systems.
- Regulations should be designed to provide for statewide availability of at least one grade of non-leaded fuel in sufficient quantity to meet the demands of the Federal New Car Program.
- Additional studies should be undertaken to assess, in more detail, the following elements
  - Emissions inventory and air quality data
  - Political and institutional implications of the strategy
  - Legal and socio-economic implications of the strategy

INTRODUCTION

The continuing degradation in ambient air quality in our urban area has been a subject of intense public concern and interest over the last fifteen to twenty years. With the promulgation of National Air Quality Standards the search for ways of ameliorating the problem of air pollution has been expanded. Since exhaust emissions from automobiles presently constitute a major source of the overall air pollution problem, they become a likely candidate for future investigation and control.

At the time the air quality standard was set forth it was recognized that some metropolitan areas would have to impose additional transportation controls in order to achieve the required levels. While this approach appears straightforward in design, a number of potential problems exist which tend to restrict the effectiveness of many transportation control proposals. The primary factor influencing the selection and implementation of additional transportation controls involves public acceptance. Unfortunately, there presently exists a wide disparity between the public's expectation of acceptable air quality and the price they may be willing to pay to achieve that level. Therefore, any transportation program designed around voluntary public action or offering unacceptable alternatives is probably doomed to failure. This situation is especially sensitive to the residents of the Phoenix area due to results of the recent motor vehicle safety program.

STUDY PURPOSE

On June 20, 1972 the administrator of the Environmental Protection Agency published notice of rule making that proposed amendments to Title 40 CFR Part 51. The act and the administration's regulations require states to take steps to reduce emissions from transportation sources in order to meet national ambient air quality standards. The Arizona State Implementation Plan [19] has been reviewed, and it was found that the plan does not inlcude transportation controls sufficient to meet Set II pollutant standards in the Phoenix-Tucson area. Subsequently, the state of Arizona has been notified to submit a detailed plan of compliance of the Phoenix-Tucson area.

This report is in partial fulfillment of that requirement. The purpose of the report is fourfold: First, to identify and assess the most promising transportation control measures to achieve the air quality standards; second, to predict the impact on future air quality of the various candidate measures; third, to develop a proposed transportation control strategy and to document potential implementation obstacles; and fourth, to formulate a timetable for monitoring the progress of the strategy.

Taken collectively, these tasks constitute a first step in meeting the air quality standards set forth by the Environmental Protection Agency. The developed results have been coordinated with city, county, state and EPA personnel to insure proper compliance and local acceptance. As such, the report hopefully reflects the thinking of the agencies who particpated in this study.

BACKGROUND

During the post World War II period, the Phoenix region has undergone a growth process common to most urban regions in North America. On the one hand, previously unattainable concentrations of specialized land uses have been achieved at the urban core while on the other hand, the percentage of regional urban activity at the city centers has declined as residential and other land use development has been characterized by horizontal expansion in dispersed, low density patterns at the region's fringes. The separation by long distances of housing, employment opportunities, stores, schools, and community service facilities has been made possible by, and at the same time created an absolute reliance upon, mechanized transportation, particularly the automobile. Staggering rates of auto utilization -- nearly 13 million vehicle miles were driven in the Phoenix region on the average day in 1972 -- coupled with the relatively high pollution emissions from automobile engines has made the auto a substantial contributor to air pollution and, along with stationary sources, a key target for pollution control strategies.

Strategies to combat the automobile-related elements of air pollution must recognize the influence of land use and travel patterns developed over time. The trips which people make each day represent a substitute for nearness. Basic personal and societal needs can only be met by maintaining these important transportation and communication links. Because trip generation is built-in to life styles and land use patterns, it will be difficult to dramatically alter the number of types of trips over a five year period.

To mollify the perceived needs of individuals and groups and to bring about fundamental changes in the alternatives which our society makes available (i.e., a transit line versus a highway) are long-term processes. This makes it all the more important to immediately begin a program for exploring and evaluating alternatives. This process could begin with a concerted educational program, designed to encourage public officials, special interest groups and individual citizens to consider our collective future in an urban industrialized society. This is an intellectual, philosophical and long-term view of the task ahead of us. This fundamental role of education should be cultivated at every level of society.

The intra state area, the Phoenix-Tucson Air Quality Control Region, is composed of the five Arizona counties of Maricopa, Gila, Pinal, Pima, and Santa Cruz. A total of 1,431,954 people reside in this region, 80.8 percent of the total state population. The region encompasses 29,753 square miles, 26.2 percent of the total state area. Due to the scarcity of data, the analysis was limited in scope to Maricopa County. Located in the Southwest-Central part of the state, Maricopa County has an area of 9.155 square miles and a population of one million (the most populous county in Arizona). Phoenix, the capital city of the state and the county seat, has a population of 968,487, largest in the state. Other cities and populations are as follows: Scottsdale, 67,823; Tempe, 63,550; Mesa, 62,853; and Glendale, 36,228. The leading industries are manufacturing, agriculture, wholesale and retail trade and tourism. The 1980 projected population of Maricopa County is 1,356,700 (40 percent growth) while that of Phoenix is 810,000 (39 percent growth).

The continuing growth of the automobile population (estimated at one million by 1980) and vehicle travel within the Phoenix area has lead to high projected concentrations of all four Set II pollutants. This situation is further aggravated by the existence of an inversion layer. The impact of this layer on air quality is extremely severe during the winter months. Peak values of carbon monoxide recorded during an extended stagnation period in Phoenix in December 1969 were substantially higher than any maximum concentration since that time. Unfortunately, the only air quality data available for use in the study came from that recording period. Data for the 1971 period has been collected, but has not been reduced to a form suitable for detailed analysis.

PROBLEM DEFINITION

Although the Arizona State Implementation Plan calls for the control of all pollutants by 1975, recent evidence indicates that without additional controls carbon monoxide, oxides of nitrogen, and oxidant levels will still exceed the national standards. The Environmental Protection Agency Administrator has extended for 2 years the attainment date (1977) for the carbon monoxide standards. Similar provisions have not been made for either oxides of nitrogen or photochemical oxidants.

The problem, taken in its simplest form, becomes one of identifying and characterizing methods for improving air quality in the Phoenix areas within the given time frame. Satisfaction of this requirement depends upon a detailed knowledge of current air quality levels and a quantification of the pollutant emissions in the region. The forecasting of air quality and the assessment of proposed methods for reducing emissions represented the other key elements in attacking the problem.

For the present study, methods for improving air quality (measures) are limited to those affecting transportation sources. That is, no attempt has been made to identify measures for controlling stationary sources above those ongoing or presently planned programs. This can, in some instances, severely limit the options available for reducing emissions in a cost effective manner.

Achieving the air quality standards in the Phoenix Area can be technically accomplished with several transportation oriented measures (e.g., vheicle use restriction). The problem is that these severe measures are politically, institutionally, legally and socio-economically unviable. Consequently, the number alternatives that are both technically (yield reasonable emission reduction) and otherwise acceptable is quite small.

TECHNICAL APPROACH

The relationships between regional emissions, proposed control measures and resultant air qualtiy are multi-dimensional and complex. To overcome these difficulties it is useful to adopt a systematic approach or framework. Such an approach offers a logical structure for developing solutions to complex socio-economic technical problems.

A three-phased approach was utilized in conducting the Phoenix-Tucson transportation control study.

- Survey of emissions inventory and air quality data
- Formulation of an air quality strategy simulation model
- Public attitude survey on potential transportation control measures

Estimates of baseline (1969) emissions and air quality were obtained from the Arizona State Implementation Plan and other public and private sources. An analysis of the relevant data set revealed large potential variances in the basic estimates. The existence of such uncertainties underscored the need for caution in assessing and interpreting the derived results.

The formulation of an air quality simulation model provided the vehicle for systematically evaluating the merits of a variety of proposed control measures. Many of the elements included in the model came from ongoing or existing programs. Figure 1 presents a schematic description of the simulation model. The model utilizes estimates of current and future vehicle demographic and emission data in developing estimates of future air quality. Also included is a description of the stationary sources for the region. Two different methods (Simple Rollback and Semi-Diffusion) are used in making air quality forecasts. The model can be used to determine the sensitivity of inputs and assumptions of estimated outcomes. This last capability becomes exceedingly important due to the basic uncertainty of the data.

The Phoenix Attitude Survey was carried out in an attempt to verify and validate the acceptability of any proposed plan. Although by no means comprehensive the survey does provide meaningful insight into the public's general attitude regarding air pollution control. The survey also yields cost estimates in what the public would support in the way of added controls.

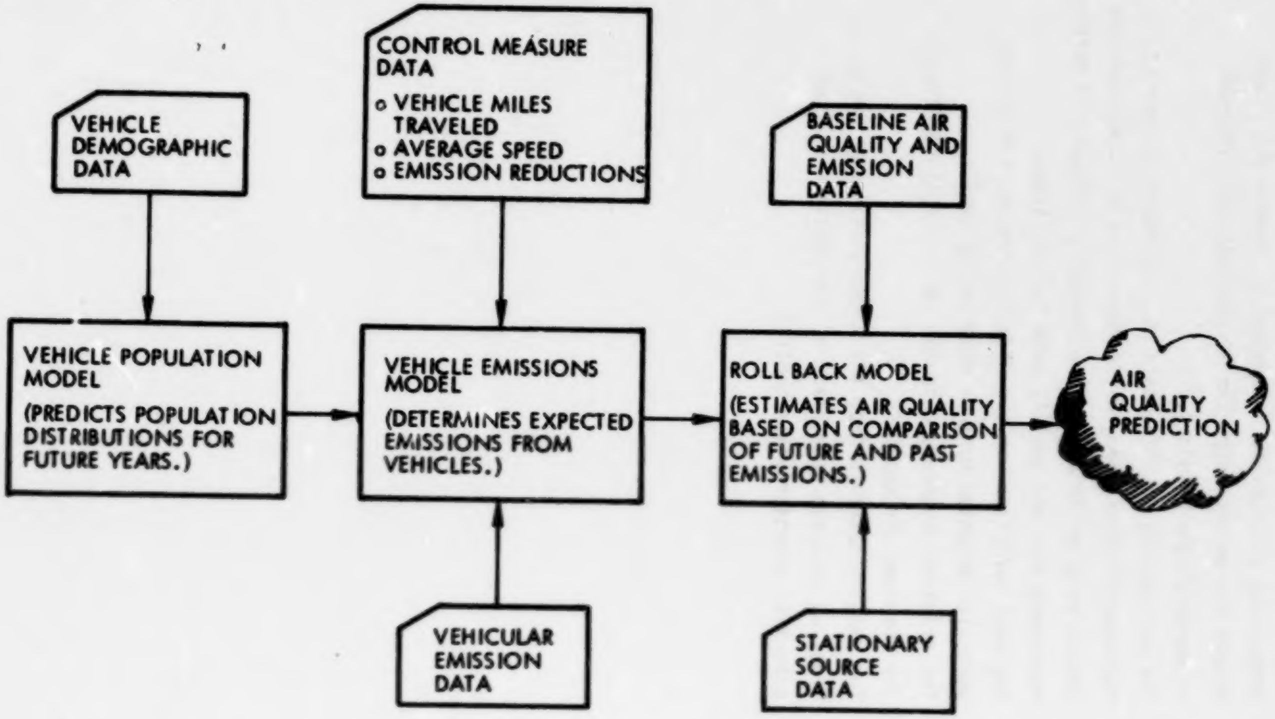
Taken collectively, these three elements constitute a first step in better understanding the air pollution problem in the Phoenix area and for identifying viable alternatives for control.

None of the above elements, and especially the forecasting model, account for the impact of large changes in the growth and development patterns of the Phoenix area. Furthermore, they do not consider the implications of technological transportation breakthroughs and/or their application for Phoenix. Consequently, results derived and discussed from this analysis should be viewed within this context.

The following presents a list of the main ground rules and assumptions used in developing the proposed transportation control strategy.

- Forecasts were made using maximum observed concentration levels for the baseline year. Since current EPA rules allow the standard to be exceeded once per year, use of the second highest observed maximums would yield the same level of future air quality with fewer controls.
- Forecasted air quality concentration levels which were within ten (10) percent of standard were assumed to be within standard.

- Forecasted air quality concentration levels which were within the uncertainty band of standard were assumed to approach the standard.
- The air quality baseline data used in making forecasts is representative of the greater Phoenix area. (Consideration should be given to using time averaging concepts in developing representative air quality data for the area.)
- Regional variations on the effectiveness of the various vehicular oriented control measures is small.
- The emission inventory data for 1969 is consistent with the observed air quality.
- The results obtained from the Phoenix Attitude Survey reflect an accurate assessment of the public's view on potential transportation control.


CONTROL MEASURE EVALUATION METHODOLOGY

VEHICLE DEMOGRAPHIC DATA
CONTROL MEASURE DATA
o VEHICLE MILES TRAVELED
o AVERAGE SPEED
o EMISSION REDUCTIONS
BASELINE AIR QUALITY AND EMISSION DATA
VEHICLE POPULATION MODEL
(PREDICTS POPULATION DISTRIBUTIONS FOR FUTURE YEARS.)
VEHICLE EMISSIONS MODEL
(DETERMINES EXPECTED EMISSIONS FROM VEHICLES.)
ROLL BACK MODEL
(ESTIMATES AIR QUALITY BASED ON COMPARISON OF FUTURE AND PAST EMISSIONS.)
AIR QUALITY PREDICTION
VEHICULAR EMISSION DATA
STATIONARY SOURCE DATA

Figure 1. Schematic of Air Quality Simulation Model

The report begins with a detailed description of air quality, emission sources, and the existing transportation system. Following that, the report deals with an assessment of various transportation control measures and the prediction of future air quality. Next, the procedures and time schedule required for implementing the control plan are discussed along with the developed surveillance program. Finally, a set of conclusions and recommendations are put forth which summarize the findings of the study and focus attention on future courses of action.

CONTROL STRATEGY DEVELOPMENT

The development of a viable strategy for improving air quality in the Phoenix area represents the key elements of this study. Developing a comprehensive plan requires a basic understanding of the existing air quality problem. This section focuses on the nature and extent of the problem. Quantitative estimates of current and forecasted concentration levels are presented along with selected air quality data.

Secondly, it identifies and discusses a broad spectrum of alternative policies to control transportation sources of pollution. The spectrum encompasses technological and non-technological approaches as well as combinations of both.

Finally, a specific strategy is proposed for ameliorating the air pollution problem in the Phoenix area. Included in this are:
1) a definitive description of the strategy, 2) an assessment of its impact on future air quality, 3) an estimate of the economic and financial implications, 4) documentation of potential implementation obstacles, and 5) an analysis of alternative measures and strategies.

BASELINE ESTIMATES

Figures 2 through 5 show monthly air quality concentration measurements for Hydrocarbons (HC), Carbon Monoxide (CO), Nitrogen Dioxide (NO_2), and Photochemical Oxidants (O_x), respectively*. The data is presented for the baseline year (1969) and for 1971. Although the concentration levels for 1971 appeared generally lower than for the baseline, this data was not used in the forecasting process. This is due primarily to the lack of supportive emissions inventory data. As can be seen the maximum concentration levels for the pollutants occur at different times of the season (i.e., HC in October, CO in January, NO_2 in November and O_x in June). The seasonal variation in concentration levels obviously compounds the problem of identifying effective control measures. The problem is further aggravated due also to diurnal variation in these pollution concentrations (see Appendix C for plots of Diurnal Concentration Data).

The observed data in Figure 6 further illustrates improvements in air quality between the 1969 and 1971 period. Panels A and B show frequency distributions of the days the standard was exceeded for CO and O_x, respectively. This obvious distinction between the 1969 and 1971 measurements clearly emphasizes the need for utilizing the latest air quality data in forecasting concentration levels. The utilization of data over 10 years old in forecasting 1980 air quality is clearly marginal. Furthermore, the use of these estimates in formulating policy cannot be justified.

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*Values plotted are monthly averages of hourly concentrations.

Estimates of future air quality were made using the air quality model. Results of these simulations for the baseline case (assuming the continuation of ongoing and current planned program but without added transportation controls) are presented in Table 2. Also shown are the National and State standards. A comparison of the forecasted results with these standards indicates the need for additional strategy control for CO (8-Hr max), NO_2 and O_x. Two estimates are presented for the CO (8-Hr max). The first one is based on the baseline values given in the Arizona State Implementation Plan while the other represents the value confirmed by this study.

The relative importance of the various emissions categories in terms of their impact on baseline air quality are shown in Tables 3 through 6 for HC, CO, NO_2 and O_x, respectively. The estimated values for 1975 and 1977 are based on the following assumptions:

- Continuation of the Federal New Car Program
- MAGTPP Five Year Program
- FAA Jet Aircraft Retrofit Program
- Hydrocarbon Process Losses Control
- Other Traffic Improvement Programs
- Normal Vehicle Attrition
- Forecast of Continued Vehicle Population Growth

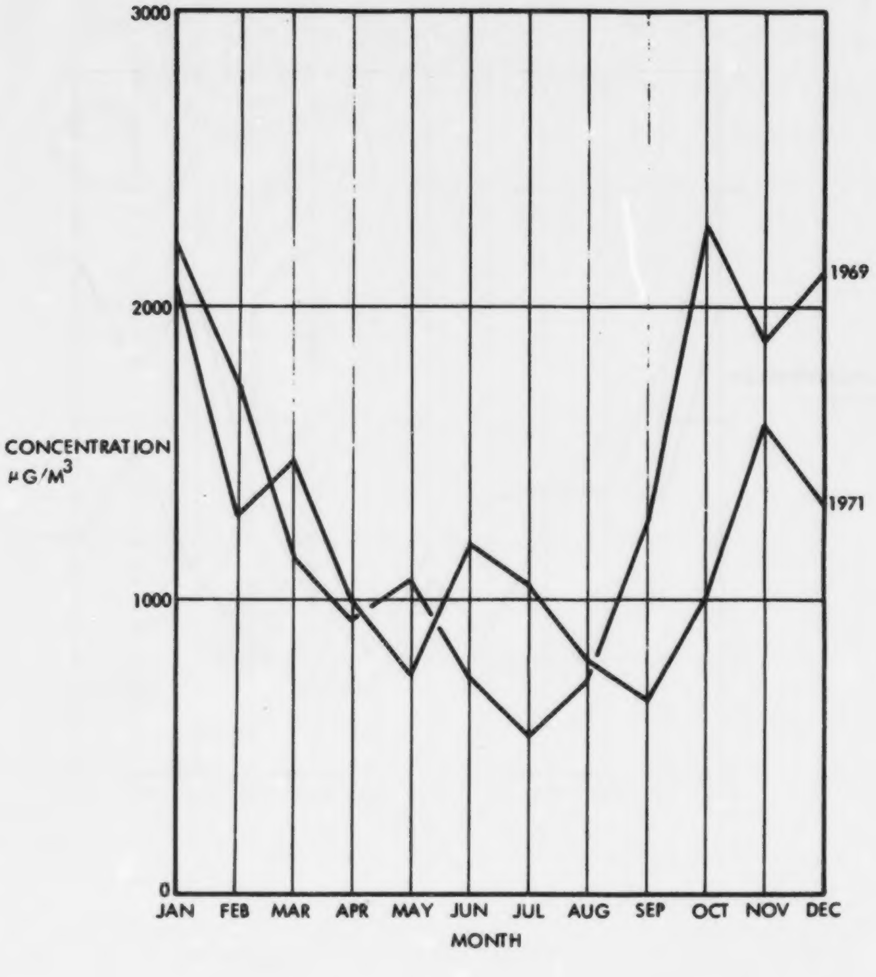


Figure 2. COMPARISON OF YEARLY TOTAL HC VARIATION IN PHOENIX IN 1969 AND 1971 (MCHD DATA)

(Values Plotted are Monthly Averages of Hourly Concentrations)

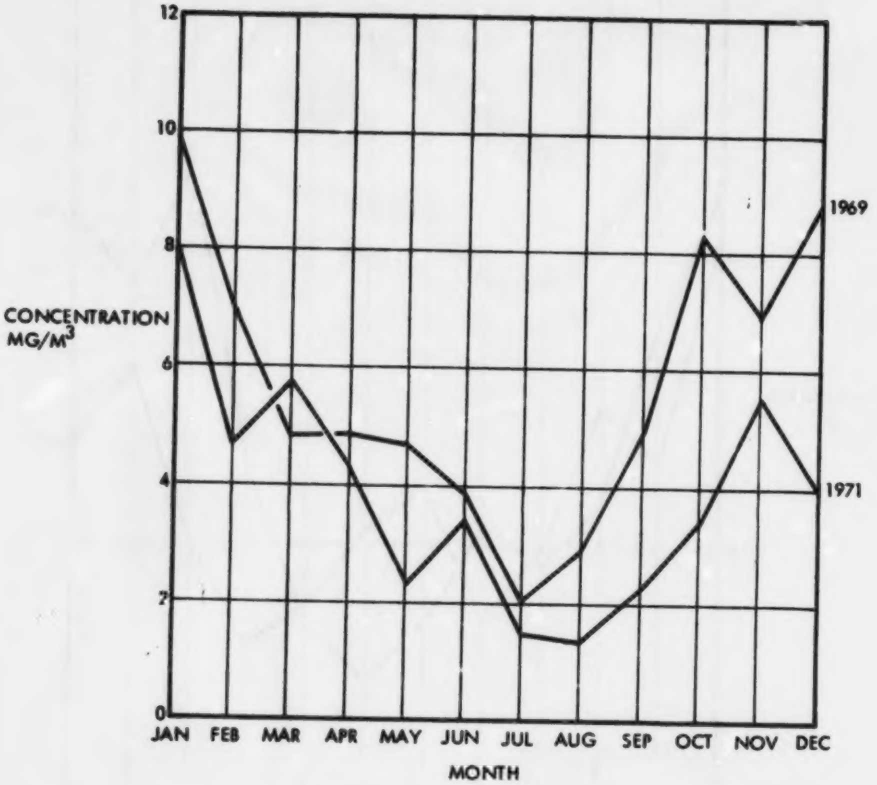


Figure 3. COMPARISON OF YEARLY CO VARIATION IN PHOENIX IN 1969 AND 1971 (MCHD DATA)

(Values Plotted are Monthly Averages of Hourly Concentrations)

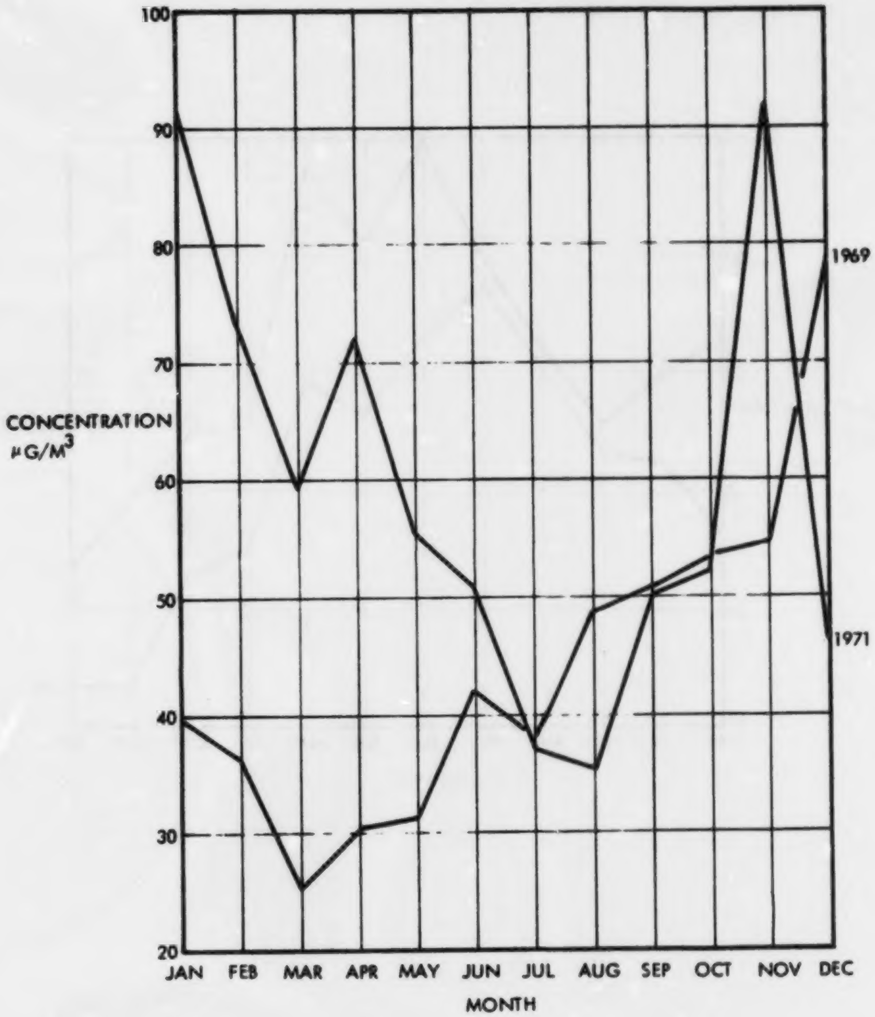


Figure 4. COMPARISON OF YEARLY NO_2 VARIATION IN PHOENIX IN 1969 AND 1971 (MCHD DATA)

(Values Plotted are Monthly Averages of Hourly Concentrations)

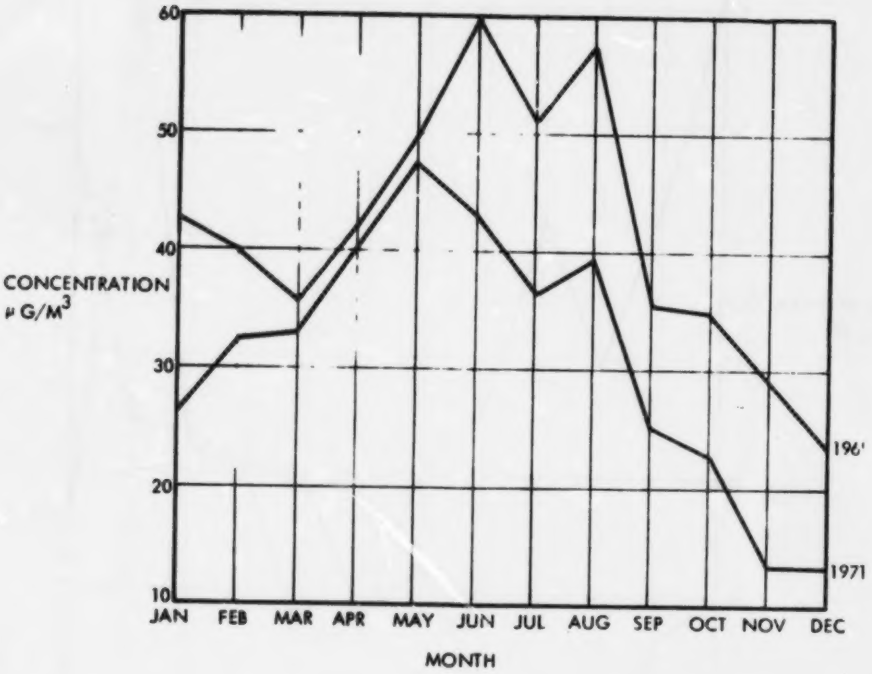


Figure 5. COMPARISON OF YEARLY O_X VARIATION IN PHOENIX IN 1969 AND 1971 (MCHD DATA)

(Values Plotted are Monthly Averages of Hourly Concentrations)

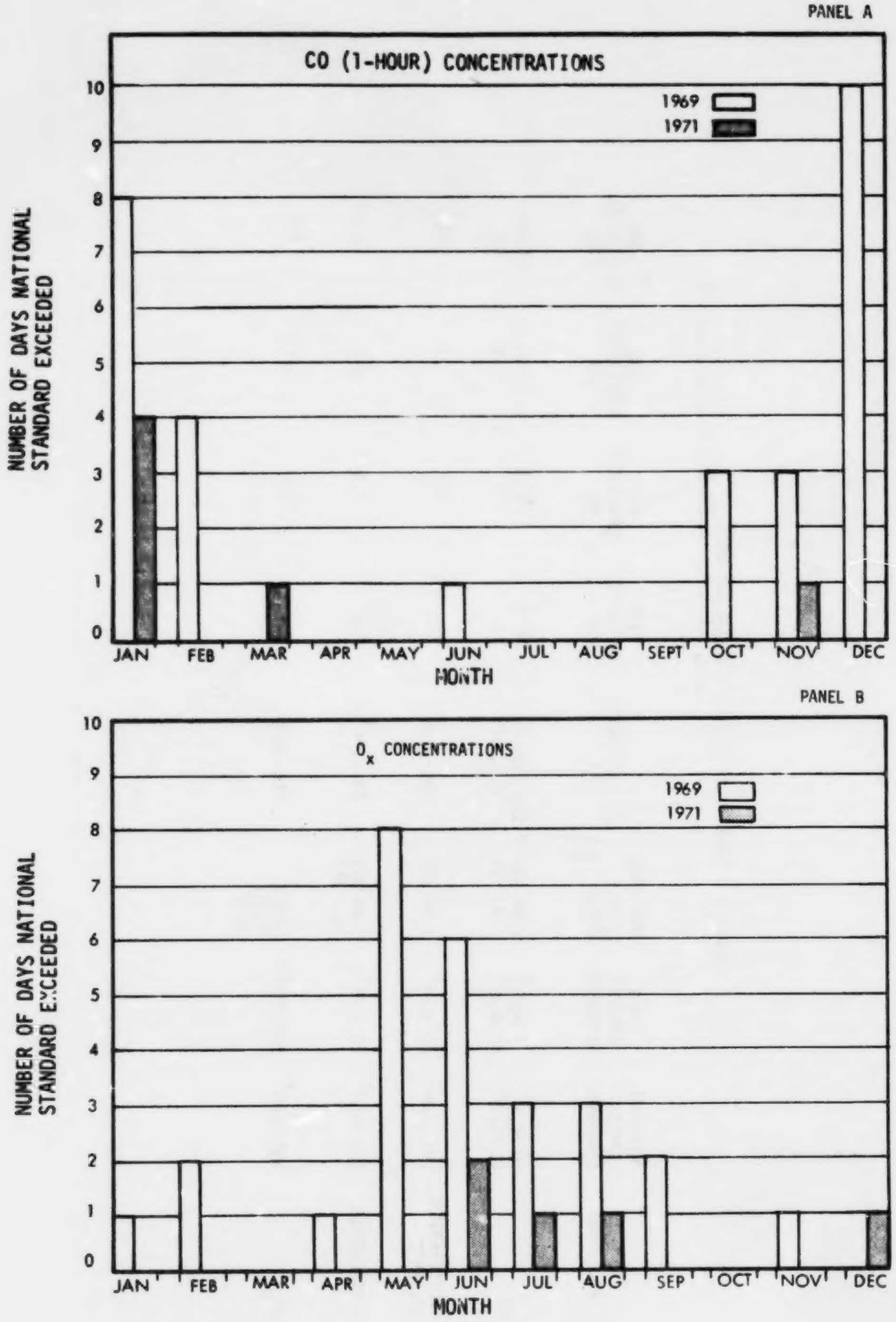


Figure 6. COMPARISON OF 1969 AND 1971 AIR QUALITY DATA

TABLE 2 SUMMARY OF PHOENIX AIR QUALITY DATA

POLLUTANT	NATIONAL AMBIENT STANDARDS	STATE AMBIENT STANDARDS	NATIONAL SAMPLE BASIS	1969 MEASURED MAX	1975 FORECASTED MAX	1977 FORECASTED MAX	1978 FORECASTED MAX	1980 FORECASTED MAX
CO	10 MG/M^3 40 MG/M^3	7 MG/M^3 40 MG/M^3	8-HR MAX 1-HR MAX	38/47 MG/M^3 58 MG/M^3	25/31 40	20/25 32	18/21 28	14/18 23
PHOTOCHEMICAL OXIDANTS	160 μG/M^3	80 μG/M^3	1-HR MAX	300 μG/M^3	233	226	224	219
HYDROCARBONS	160 μG/M^3	80 μG/M^3	3-HR MAX (6-9 AM)	13 μG/M^3	6.6	5.9	5.7	5.5
NO$_x$	100 μG/M^3	100 μG/M^3	ANNUAL ARITH MEAN	168 μG/M^3	254	227	214	208

Table 3. RELATIVE EMISSIONS OF NONMETHANE HYDROCARBONS BY SOURCE CATEGORIES

(Sample Basis: 3-Hour Average)

Source Category	1969 Emissions (Per Cent of Total)	1975 Emissions (Per Cent of Total)	1977 Emissions (Per Cent of Total)
Uncontrolled Vehicles[a]	29.7	12.4	7.6
Controlled Vehicles[b]	6.4	7.4	6.5
Post-1970 Vehicles	Negligible	14.9	14.5
Heavy-Duty Vehicles	11.1	19.9	21.6
Crankcase & Evaporative Losses	26.1	18.1	14.7
Filling Stations	4.3	11.6	16.2
Diesel Vehicles	Negligible	Negligible	Negligible
Metallurgical Processes	Negligible	Negligible	Negligible
Industrial Processes	Negligible	Negligible	Negligible
Aircraft	3.8	1.9	2.4
Bulk Fuel Terminal	3.6	7.0	8.7
Open Burning Dumps	Negligible	Negligible	Negligible
Power Plants	0.6	1.8	2.5
Process Losses	14.5	4.3	5.3
Total	100%	100%	100%

Note:

All values in this table are for the baseline case; i.e., no control measures recommended in this report have been applied.

---

[a] Pre-1968 vintage

[b] 1968 through 1970 vintage

Table 4. RELATIVE EMISSIONS OF CARBON MONOXIDE BY SOURCE CATEGORIES

(Sample Basis: 8-Hour Average)

Source Category	1969 Emissions (Per Cent of Total)	1975 Emissions (Per Cent of Total)	1977 Emissions (Per Cent of Total)
Uncontrolled Vehicles[a]	59.2	22.0	14.9
Controlled Vehicles[b]	16.4	19.9	19.5
Post-1970 Vehicles	Negligible	27.7	29.5
Heavy-Duty Vehicles	17.5	28.7	33.8
Crankcase & Evaporative Losses	Negligible	Negligible	Negligible
Filling Stations	Negligible	Negligible	Negligible
Diesel Vehicles	Negligible	Negligible	Negligible
Metallurgical Processes	0.4	0.7	1.0
Industrial Processes	Negligible	Negligible	Negligible
Aircraft	2.1	1.0	1.4
Bulk Fuel Terminal	Negligible	Negligible	Negligible
Open Burning Dumps	4.4	Negligible	Negligible
Power Plants	Negligible	Negligible	Negligible
Process Losses	Negligible	Negligible	Negligible
Total	100%	100%	100%

Note:

All values in this table are for the baseline case; i.e., no control measures recommended in this report have been applied.

---

[a] Pre-1968 vintage

[b] 1968 through 1970 vintage

Table 5. RELATIVE EMISSIONS OF CARBON MONOXIDE BY SOURCE CATEGORIES

(Sample Basis: 1-Hour Average)

Source Category	1969 Emissions (Per Cent of Total)	1975 Emissions (Per Cent of Total)	1977 Emissions (Per Cent of Total)
Uncontrolled Vehicles[a]	62.6	22.1	15.0
Controlled Vehicles[b]	17.3	20.1	19.7
Post-1970 Vehicles	Negligible	27.9	29.8
Heavy-Duty Vehicles	18.5	28.9	34.1
Crankcase & Evaporative Losses	Negligible	Negligible	Negligible
Filling Stations	Negligible	Negligible	Negligible
Diesel Vehicles	Negligible	Negligible	Negligible
Metallurgical Processes	0.3	0.4	0.6
Industrial Processes	Negligible	Negligible	Negligible
Aircraft	1.3	0.6	0.8
Bulk Fuel Terminal	Negligible	Negligible	Negligible
Open Burning Dumps	Negligible	Negligible	Negligible
Power Plants	Negligible	Negligible	Negligible
Process Losses	Negligible	Negligible	Negligible
Total	100%	100%	100%

Note:

All values in this table are for the baseline case; i.e., no control measures recommended in this report have been applied.

---

[a] Pre-1968 vintage

[b] 1968 through 1970 vintage

Table 6. RELATIVE EMISSIONS OF NITROGEN OXIDES BY SOURCE CATEGORIES

(Sample Basis: Annual Arithmetic Mean)

Source Category	1969 Emissions (Per Cent of Total)	1975 Emissions (Per Cent of Total)	1977 Emissions (Per Cent of Total)
Uncontrolled Vehicles[a]	21.1	2.6	1.6
Controlled Vehicles[b]	19.6	5.6	4.9
Post-1970 Vehicles	Negligible	15.1	14.9
Heavy-Duty Vehicles	15.5	9.8	12.7
Crankcase & Evaporative Losses	Negligible	Negligible	Negligible
Filling Stations	Negligible	Negligible	Negligible
Diesel Vehicles	10.2	6.3	8.1
Metallurgical Processes	Negligible	Negligible	Negligible
Industrial Processes	5.8	3.5	4.5
Aircraft	2.6	1.6	2.0
Bulk Fuel Terminal	Negligible	Negligible	Negligible
Open Burning Dumps	1.1	Negligible	Negligible
Power Plants	24.1	55.6	51.2
Process Losses	Negligible	Negligible	Negligible
Total	100%	100%	100%

Note:

All values in this table are for the baseline case; i.e., no control measures recommended in this report have been applied.

---

[a] Pre-1968 vintage

[b] 1968 through 1970 vintage

CONTROL MEASURE ASSESSMENT

A wide range of promising control measures was assessed during the course of the analysis. Table 7 presents a list of general measures considered for this study. Broadly speaking, these measures can be classified into two major areas: 1) vehicle emission control and 2) vehicle population control.

Measures common to the first category are vehicle inspection/maintenance and vehicle retrofit. These programs are designed to reduce emissions on a per vehicle bases. They are generally easier to characterize in terms of performance and cost than programs designed to reduce vehicle travel. However, they normally yield, on the average, less emission reduction results than many of the more restrictive population control programs.

Population oriented programs are designed to reduce emission levels from the aggregate vehicle fleet. These include improvements in the traffic system, acceleration of attrition of older vehicles and vehicle travel reductions. Basically, there are three ways to reduce the total amount of motor vehicle travel within a metropolitan area: regulation, pricing, and demand shift to other transportation modes.

The following presents some discussion on the salient features of each of the control measures listed in Table 7.

Table 7. CANDIDATE CONTROL MEASURES

Vehicular Oriented

- Inspection/Maintenance
- Retrofit
- Fuels Modification
  - Lowering Reid Vapor Pressure
  - Replacing Reactive Hydrocarbons
  - Lead Removal
  - Gaseous Fuel Conversion

Vehicle Population Oriented

- Traffic System Improvements
- Vehicle Exchange

Vehicle Travel Reduction

- Regulation
  - Limited Registration
  - Fuel Rationing
  - Travel Rationing
  - Parking Limitations
  - Free Zones
  - Work Schedule Shifts
- Pricing
  - Increase Cost of Ownership
  - Increase Fuel Taxes
- Demand Shift
  - Improve Mass Transit Service
  - Slow Traffic Improvements

Vehicle Inspection/Maintenance

A program of mandatory vehicle inspection/maintenance (I/M) represents one short term approach for controlling exhaust emissions from automobiles. A program of I/M is in principle, a simple yet adaptive approach which has an effect on all vehicles in the population. Automotive emission control through I/M can be accomplished by employing any one of a number of basic procedures. In general, an I/M program requires a periodic inspection of each vehicle in the population to determine whether or not it conforms to existing emissions standards or manufacturer specifications. Those vehicles failing the inspection procedure are required to undergo subsequent maintenance to return their emission levels to acceptable levels. All cars, both old and new, feel the direct impact of this control approach.

The State of Arizona presently has underway a three-part vehicle inspection and testing program. Part One involves the erection of a prototype inspection station and testing laboratory for engineering and technical evaluation of various inspection and maintenance procedures (scheduled in July 1972). Part Two calls for the initiation of a mandatory vehicle emission inspection program in Phoenix Intra-State Region (to begin in July 1973). Finally, Part Three expands the program to a statewide basis beginning July 1975. While specific inspection and maintenance procedures have not been defined, the selection of a state lane emission test program appears most appropriate. Cost effective studies have shown that a yearly exhaust emission inspection under load, followed as necessary by corrective maintenance yields optimal results. The most cost effective maintenance treatment involves the adjustment and/or replacement of the following engine components: idle air/fuel ratio, ignition (misfire), air cleaner and PCV. Since maintenance plays the key role in a mandatory program, steps should be taken to improve the overall reliability and uniformity of service garage performance. One such step could be the licensing of mechanics.

I/M has the advantage of having a fairly predictable impact on emissions. Since it is a compulsory program it does not depend upon any unpredictable behavioral response patterns on the part of vehicle owners. The requirement of periodic I/M together with knowledge of the vehicle population characteristics is sufficient to predict the control impact with a reasonable degree of accuracy.

It is important to recognize, however, that a compulsory program would still not impact equally on all owners from an economic standpoint. Since it is a strategy that focuses on older cars and those whose owners are less likely to maintain them to high standards, the economic burden of I/M would fall proportionately more on lower income than high income groups. These individuals also typically have few alternatives in terms of either public transporation or the purchase of a newer vehicle. What I/M may require then is a set of partially offsetting public subsidies such as:

a) State or Federal tax deductibility.
b) Prorated cost based on income with the balance covered from general tax revenues which would be obtained through a progressive tax structure.
c) Welfare assistance.

There is a need in this strategy design for utilizing an equitable distribution of the financial burden according to ability to pay while retaining control tactics which discriminate against high emission vehicles.

Other relevant economic concerns relate to the costs of maintenance. The short run elasticity of maintenance capacity is fairly low. This means then that the initiation of an I/M program will lead to inflated mechanic and repair costs for everyone, not only the individual who is forced by I/M to maintain his car to a higher than desired standard. This is likely to create general concern among the public regarding the reliability of the strategy and may necessitate public policy designed to eliminate or at least lessen the short run maintenance shortage.

Retrofit Systems

A retrofit program has some of the same characteristics as inspection/maintenance. It is even more of a short run strategy since it focuses on older cars that, due to attrition, are likely to account for only a minor portion of vehicle population by the mid-1970's. For that group, though, predictability of control effectiveness is high so that the reduction achieved by retrofit can be known to within reasonable limits.

The distributional effects of retrofit are even clearer than for inspection/maintenance. Since it focuses purely on precontrol vehicles, its costs would be born primarily by lower income groups. Without any offsetting subsidy program, the discriminatory economic impact of retrofit, compared with its purely short run effects, may negate its general attractiveness.

An estimate of the average cost of retrofit can be obtained quite easily. This figure ranges from about 30 to 50 dollars/year including both proration of the initial purchase and installation cost and estimate of direct costs of operation and maintenance. If this cost were averaged over the entire vehicle population, it would not differ significantly from the overall average cost of inspection/maintenance. Again, this masks the very real distributional questions mentioned above. above.

Presented below is a brief discussion of the technical and economic elements of the various systems. For this study, the values used for average emission reduction per vehicle were adopted from EPA estimates.

Vacuum Spark Advance Disconnect

A highly attractive approach. Reductions of HC and NO_x of from 30% to 50% have been demonstrated. There are no durability problems unless override mechanisms are included. Even with overrides durability should be good. Driveability and fuel economy will deteriorate moderately on average. However, some vehicles may have sizeable fuel economy reductions (perhaps 20%). Costs, including labor and simple override mechanisms, should be from $15 to $30. Overheating is hot climates and reported exhaust valve burning are possibilities which need to be investigated more thoroughly.

Lean Idle Setting

Has good possibilities except for a high probability of owner or mechanic tampering. Fair to low reductions in HC and CO can be expected depending on the average state of the population (5% to 20%). The only durability problems would be due to carburetor deterioration (fuel deposits) and the above mentioned tampering due to an expected decrease in idle quality, to which most owners are sensitive. Fuel economy should improve only very slightly on average (5% would be good). The cost should be nominal - $3 to $6. The ease of performing this modification is theoretically simple, but mechanic ability and instrumentation limitations in the field indicate that 50% performance is presently a high estimate.

Exhaust Catalysts

Oxidizing catalysts are now avilable which offer substantial reductions in HC and CO (maybe up to 90%). Dual bed catalysts (oxidizing plus reducing) are currently being developed which also offer reductions in NO_X (maybe 50%). At least for the case of the oxidizing catalyst, the reductions in emissions are not realized until warm-up has taken place. The greatest concern with catalyst durability is poisoning due to even low levels of lead, phosphorous, and sulfur in currently available fuels. Another possible problem, with catalyst being installed on older and probably very dirty vehicles, is extreme heat being generated causing damage to either the catalyst and its container or nearby vehicle components. The cost of catalysts will probably come down substantially as they become production items in 1975. Estimates of retail prices range from $40 to $90. Installation should be easy and almost fool-proof.

Air Bleed

In general, a "well designed" air bleed will accomplish about the same reductions as a lean idle setting (see above), or leaner carburetor jets. Durability should be no problem, driveability would suffer, installation should be generally easy, and cost should be low.

Basic Timing Retard

This would offer the same benefits as VSAD (see above) except that reductions would be lower unless timing is retarded severely (on the order of 10 to 15 degrees). The penalties would also be the same except that cost would be less ($2 to $4) and owner tampering would be probable.

Exhaust Gas Recirculation

This offers reductions primarily in nitrogen oxides - probably in the range of 30% to 50%. OEM installations that are currently in use have obviously demonstrated 50,000 mile durability. However, field experience indicates that high leaded fuels and possibly malfunctioning engines (misfire, carburetor flooding, and oil burners) may cause plugging. Repairs due to plugging should not be too difficult. Driveability is certainly expected to suffer - from mild to severe. Fuel economy is expected to deteriorate to some degree, also. The retail costs, which includes installation in this estimate, are expected to range from $40 to $65. Installation can be performed with only slight difficulty, provided minimal training is supplied.

Evaporative Emission Control

Evaporative losses from the carburetor and fuel tank account for an estimated 25% of the average vehicles hydrocarbon emissions (or about 15% of the total hydrocarbon emissions in the Phoenix area). Additionally, evaporative losses from gasoline marketing (filling automobile tanks and service station tanks) constitute another 5% of the total. Control of evaporative losses from automobiles has been in effect nationally since 1971.

The cost of controlling operating losses from older vintage cars (pre-1971) with "add-on" hardware devices appears prohibitive. However, a substantial reduction can be achieved through the reduction of low volatility gasoline. Studies have shown [23, 24] that a 2.0 psi reduction in Reid vapor pressure (from 9.0 to 7.0) would reduce evaporative emissions by more than 30%. It appears that public acceptance of low volatility gasoline will be satisfactory.

Such a reduction may increase the photochemical reactivity of the evaporated hydrocarbons, depending on the type of process change made at the refinery. However, studies indicate [23, 34, 37] that this change is small and that it does not strongly affect the efficacy of this increase. In addition, other refinery process changes (typically involving substitution of certain C_4 and C_5 hydrocarbons) which reduce the reactivity per gram of the gasoline product may be made at the same time the RVP is lowered. The ultimate effect would be a double reduction in reactive hydrocarbon evaporative emission. Several methods have been proposed for determining reactivity scales based on constitnent hydrocarbons [37, 38, 39].

Effective control of evaporative marketing losses is also well within the current state of technology. For the gasoline tank, the most straightforward approach involves a vacuum return line from the pump nozzle to the storage tank. This allows the vapor accumulated in the gas tank to flow back to the storage tank or recovery unit instead of venting to the atomosphere. Approximately 70% of the vehicles on the road (mostly domestic) can be serviced from one adaptive pump nozzle. Such an approach would recover about 70% of tank filling vapors upon the installation of the appropriate hardware became standardized.

Recovering evaporative losses from auto gas tank filling and from (either during filling operation or normal venting) can be accomplished with a condenser or a charcoal canister device which absorbs excess vapors. Vapors accumulated in the underground storage tanks are displaced back to the fuel supply truck during each delivery (closed system). Recovery of the vapors in the supply truck is accomplished at the fuel supply terminal. Regeneration of the charcoal canisters and condenser units should also be undertaken at the fuel supply depot. Figures 7 and 8 depict schematically the principle characteristics of the two most promising systems for controlling marketing losses while Figure 9 shows present and proposed standards for regulating maximum Reid vapor pressure of gasoline. (Note that the lower RVP standard is proposed only during spring, summer, and fall months -- the period during which O_x standards are exceeded in Phoenix.)

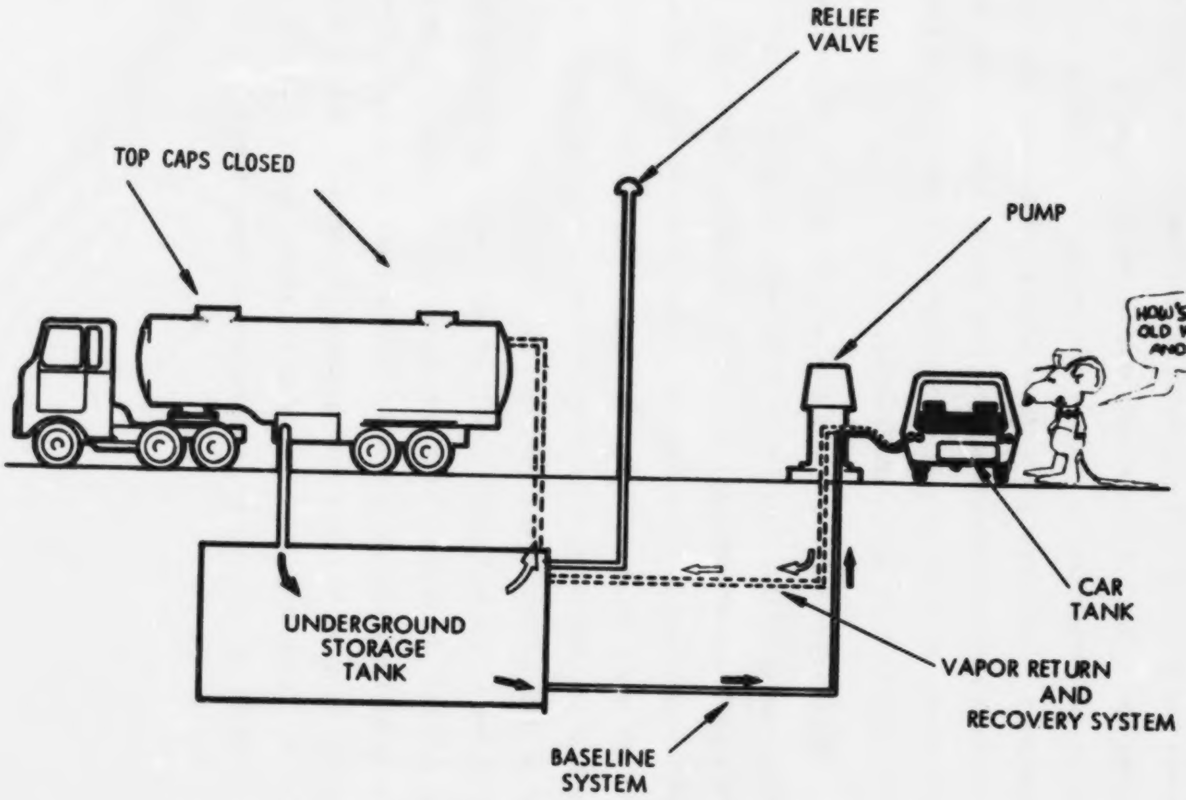

RELIEF
VALVE
TOP CAPS CLOSED
PUMP
HOW'S THE
OLD WATER
AND OIL?
UNDERGROUND
STORAGE
TANK
CAR
TANK
VAPOR RETURN
AND
RECOVERY SYSTEM
BASELINE
SYSTEM

Figure 7. VAPOR RETURN AND RECOVERY SYSTEM FOR EVAPORATIVE LOSS CONTROL

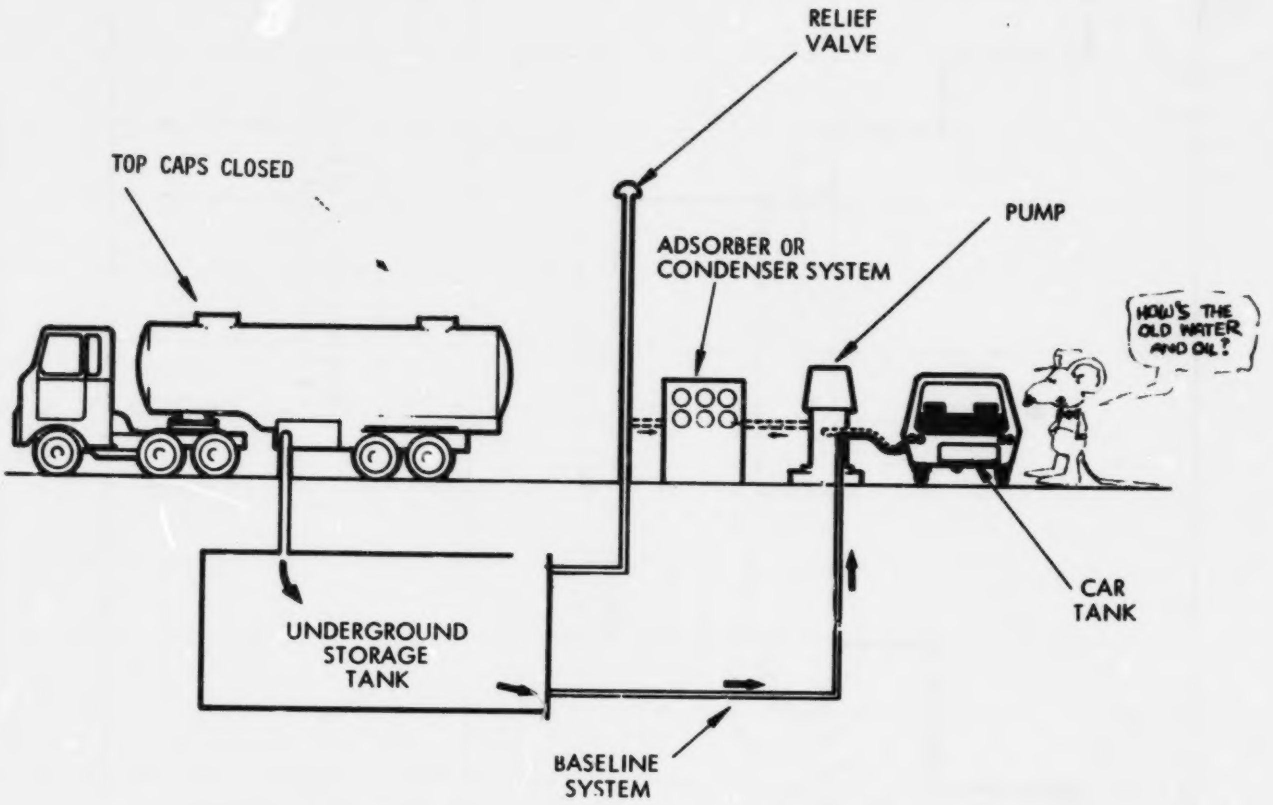

RELIEF VALVE
TOP CAPS CLOSED
PUMP
ADSORBER OR CONDENSER SYSTEM
HOW'S THE OLD WATER AND OIL?
CAR TANK
UNDERGROUND STORAGE TANK
BASELINE SYSTEM

Figure 8. ADSORBER OR CONDENSER SYSTEM FOR EVAPORATIVE LOSS CONTROL

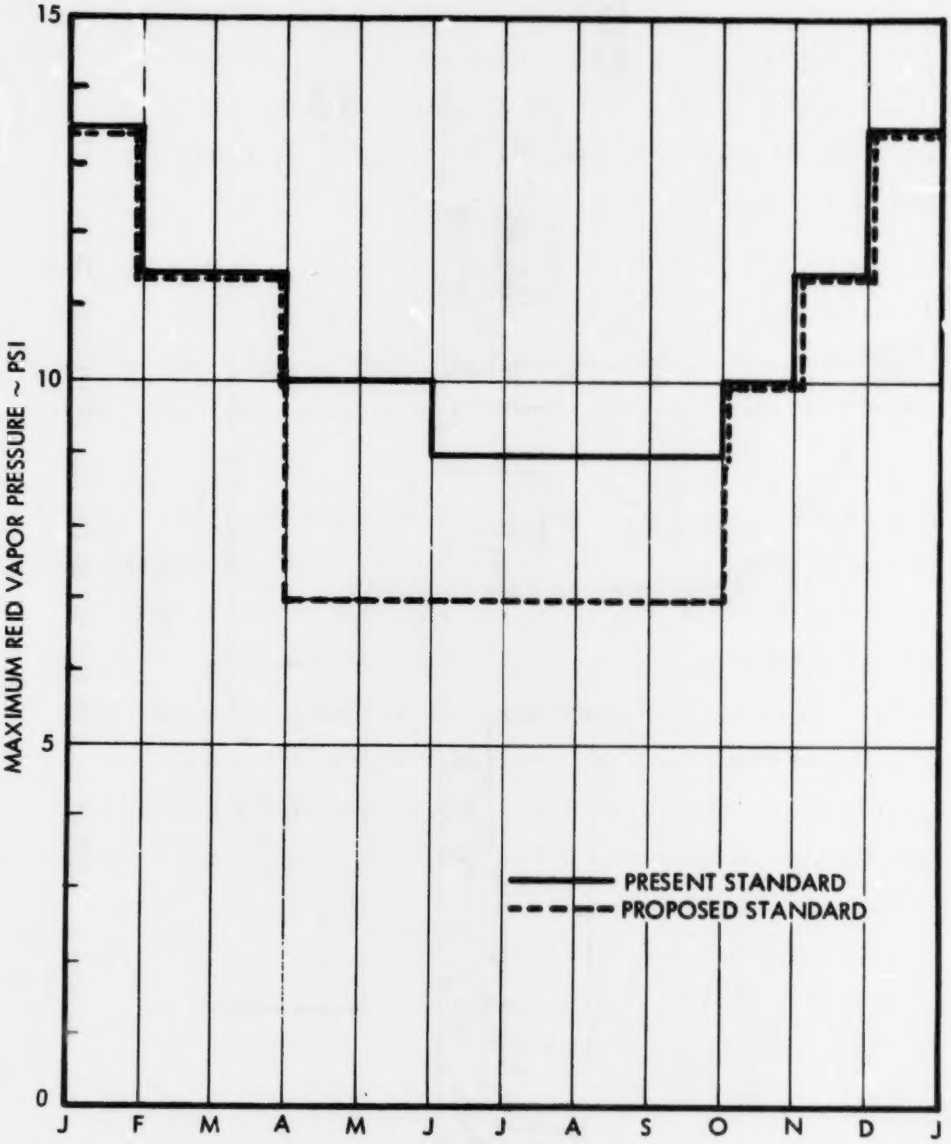


Figure 9. PRESENT AND PROPOSED REID VAPOR PRESSURE STANDARD

Gaseous Fuel Conversion

Liquefied Petroleum Gas (LPG) has been used as an automotive fuel for many years, usually because it provided an economic advantage. LPG is available in limited quantities in urban areas across the nation. About 300,000 LPG-powered vehicles are estimated to be in operation at this time.

Natural gas is also used as a motor fuel and has greater capabilities for reducing emissions than LPG. Natural gas is used in two forms; Liquefied Natural Gas (LNG) and Compressed (CNG). Gaseous-fueled vehicles are currently being operated experimentally throughout the country, mostly using CNG.

Components for conversion to gaseous fuel operation are produced by several manufacturers. Some systems are more successful than others in lowering emissions while maintaining acceptable vehicle driveability. While gasoline-gaseous dual-fuel systems greatly increase the driving range of the vehicle and provide a reserve fuel supply for emergencies, they require compromises for either fuel from performance, fuel consumption and emission standpoints. The degree of compromise of one fuel over the other depends on the utilization of the fleet vehicle. The operating ranges of vehicles fueled by LPG or LNG are comparable to gasoline fueled vehicles, but CNG fueled vehicles are usually limited in range to about 70 miles, although new tank designs have increased the range to approximately 100 miles.

Due to the limited number of fleet oriented vehicles in the Phoenix area (the entire state has only about 250 taxi cabs) the conversion to gaseous fuels does not look particularly attractive. Questions of and distribution further compound the problem.

Traffic System Improvements

This approach is designed to improve traffic flow by upgrading the City of Phoenix traffic signal system to operate under direct computer control. A 1971 study by Peat, Marwick, Mitchell and Company recommended modification of the existing system, comprised of some 240 signalized intersections, to accept direct computer control. This would provide unlimited timing options, increased traffic responsiveness and system expandibility. According to the PMM report, the computerized control system, even if the Papago Freeway were not completed by 1977, would result in a reduction in travel time on the streets affected of 8.5 percent, or in other words, would increase average travel speed by 8.5 percent. If the Papago Freeway were completed, the travel time reduction or speed increase on the affected streets would be 6.5 percent. These changes would affect some 1.95 million vehicle miles of operations on the average day. However, travel time studies (Valley Area Traffic and Transportation Study, Report No. 7) indicate that less than 20 percent of the operations on the urban major and urban collector streets affected by the signal system improvement are in the critical range below 20 miles per hour. Thus, the impact of the system in terms of emission reduction is likely to be small.

Implementation is programmed for Fiscal Year 1972/1973. System cost of $750,000 will be funded through TOPICS program. The City of Phoenix has a well qualified and efficient Department of Traffic Engineering which will operate and maintain the system.

Numerous other projects designed to improve traffic flow in the area through operational improvements such as channelization, signalization, intersection widenings, addition of lanes and provisions of grade separations, are programmed for completion during the period of concern.

Under the auspices of the Maricopa Association of Government Transportation Planning Program, a five-year program, 1972 through 1977, for transportation facilities improvements by all jurisdictions in the area has been prepared. Of the $400 million program, $306.5 million is allocated to construction of 26.1 miles of new freeway facilities and is considered separately. An additional $53.1 million is devoted to drainage, pavement resurfacing and other elements not directed to traffic flow improvements. Some $38.6 million over the FY 1972-73 period is allocated to traffic flow improvements such as channelization, signalization and widening. These latter projects will affect a total of some 79 miles of streets and highways excluding the City of Phoenix computerized signal system described previously. The subject projects are programmed, priority-ranked improvements of the MAGTPP component jurisdictions. Project costs have been estimated and anticipated funding sources have been determined.

While the individual projects included in this program are likely to have significant localized impact on traffic flow, the impact on area-wide average travel speed is likely to be quite small, probably on the order of about 2 to 3 miles per hour. Such a change will likely result in only marginal reductions in emissions.

Vehicle Exchange Program

This is another strategy aimed at controlling emissions of older vehicles, only now their actual retirement would be publicly encouraged. The existence of a fleet of state-owned vehicles which is turned over every few years creates a car pool which could be transferred in priciple to owners of older cars in return for their retirement. This plan is, however, fraught with several problems.

First, the potential vehicle pool is limited by the needs of the state and would therefore represent only a small percentage of the total vehicle population. Its impact on the population characteristics would then be small. Second, given a limited number of vehicles available, they would have to be rationed among potential "trades" through some mechanism to maximize the number of old vehicles eliminated and thus to maximize the reduction in emissions. But any non-price mechanism would necessarily lead to "winners" and "losers" and a politically undesirable situation. It is therefore not clear that an efficient mechanism for rationing the vehicles could be established that would be free of undesirable political overtones, particularly in light of the program's modest potential for reducing emissions.

Limited Second Vehicle Registration

In general, vehicle use restrictions are socially and politically difficult strategies to sell for they bring the broader cost/benefit question of control right down to the fundamental questions of personal mobility. Our society places a premium on individual mobility and any public action which restricted this mobility would face strong social and political opposition, particularly if the benefits of reduced mobility are vague and uncertain while its costs are all too obvious.

Any vehicle use restrictions which might be unnecessary in the long run could bring about undesirable changes in patterns of work and living in the short run as individuals attempted to adjust to the new mobility constraints. They would particularly discriminate against those individuals whose short run flexibility in living and business patterns were severely limited. In addition, such restrictions would cause modal-mix problems and impose higher burdens on modes other than private vehicles. This would obviously cause short run supply problems in these modes and necessitate additional capital investment in them in the long run.

Fuel/Travel Rationing

The rationing of fuel and/or travel represent two of the most severe measures suggested to date. Although highly quantifiable in context, they are both socially regressive and the legal status is unclear.

Gasoline rationing could lead to major distortions in the gasoline market and a black market could develop. In addition, no good criterion for rationing is apparent. It would, therefore, be difficult to establish rationing on a meaningful and equitable basis. Gasoline was rationed on a nation wide basis during World War II. Gasoline rationing would have a greater affect on mobility in the Phoenix area today than it did during the War. A low level of cooperation from the motoring public should be expected from any gasoline rationing program.

Rationing travel poses similar problems. It would be particularly difficult to enforce. It would undoubtedly bring about major distortions in driving behavior that would be socially disfunctional and could even weaken the effectiveness of control. Again, no equitable criterion for determining a distribution of allowable mileage is apparent, particularly in light of short run inelasticity in living and work patterns and the large variation in such patterns among the population as a whole. As with gasoline rationing, distortions in living and work patterns would be generated with no obvious long run purpose or design. Modal mix problems would also be accentuated, with the obvious short run supply problems within alternate modes.

Parking Limitations

Control of parking either through pricing policies or by direct regulation of the availability of spaces has been proposed as a means of discouraging auto travel to central cities for purposes of VMT reductions. However, a number of factors limit the potential effectiveness of this potential application in Phoenix.

Price elasticity of parking demand is not well documented. But experience in cities with close parking supply-demand relationships and high parking fees (daily rates on the order of $2 to $3 or more) indicates that parking demand (auto use) is insensitive to price to a high degree.

Where parking controls (pricing or availability limitation) are in force, the tendency is for motorists to drive to the boundary of the restricted district and park there. This is particularly true in areas where a high level of public transit service is not or cannot be provided as an alternative to auto usage.. The result would still be desirable if the problem were a localized hot spot but in Phoenix the problem is area wide and virtually all the CBD travellers' VMT has been generated by the time they reach the boundaries of the restricted district.

Parking pricing or reduced availability schemes could reduce central district property values and negatively affect central area retail trade. Over time this may reinforce the tendency to decentralized development of retail and employment activities, increasing auto travel and decreasing the potential for transit usage.

An additional negative impact of parking availability limitation is that additional VMT may be generated in the CBD by vehicles circling blocks (at low speeds which produce disproportionally high emissions) seeking the scarce spaces.

However, most damning in the Phoenix context is the fact that CBD oriented travel constitutes such a small percentage of regional travel that even if 100 percent of the VMT generated by travel to and from that area were eliminated, only a marginal reduction in area wide VMT could be identified. Despite all the factors which limit their effectiveness, programs to restrict parking in major activity centers are assessed as having positive, although marginal, impact on air quality and emission reductions. Some measures which could be implemented in Phoenix, but for which no emission reduction credit has been taken, include:

- Strict enforcement of all existing parking regulations
- Elimination of preferential rates for all-day parking
- Elimination of free parking for state and city governmental employees
- Adopt regulations to control development and pricing of off street parking
- Higher metered parking rates

Vehicle Free Zones

This approach bans motor vehicles from a single street (pedestrian mall treatment) or from a more extensive area such as the central business district. Bans could apply to all vehicles or selected vehicle types. Banning some or all motor vehicles from certain areas would obviously eliminate emissions in these areas. However, a number of factors reduce the potential effectiveness of this strategy in Phoenix.

In most mall treatments, to maintain the economic vitality of the area, copious parking is provided accessible from parallel streets. Thus, the mall treatment does not generally result in a reduction in auto travel but, at best, no change in the VMT. Additionally, there is a tendency to induce congestion on streets adjacent to the mall area. Emission reductions resulting from a mall treatment are highly localized and actually are not emission reductions but shifts of emissions to parallel streets. The larger scale ban as applied to a whole central business district might in some cases, produce significant emission reductions. But public transit in Phoenix at its current and planned levels of operation would not provide sufficient service to be the primary access mode if a large portion of the CBD were closed to motor vehicle traffic. Substantial provisions for parking at the fringes of the "vehicle free" area would be workable but the only emissions reductions resultant would be from elimination of a few blocks of travel within the vehicle-free area itself; most of the VMT on trips destined for the affected area would be run up before reaching the fringe parking areas. More remote parking facilities with park and ride transit operations could counter this problem but the low residential density in the Phoenix area and the dispersed pattern of trip origins and destinations makes it difficult to identify corridors for potential park and ride operation.

Due to the absence of a highly developed radial and circumferential freeway system, substantial traffic on central Phoenix surface streets is passing through rather than originating in or destined for the central area. Traffic bans over a large portion of the central area would tend to concentrate the through traffic on streets bordering vehicle-free zone resulting in increased VMT's due to less direct routings and possibly producing congestion.

In summary, the emission reduction potential is small and localized in nature unless an extensive park and ride system can be developed. Some emissions increase can be expected due to adverse effect on through trips using central area surface streets. Lead time would be required for development of fringe parking and a park and ride system. This can be implemented prior to 1977. Emission reductions would be principally localized in "Vehicle-Free Zones." Size of the zone is dependent on emission reduction desired, ability to provide peripheral parking and/or alternative access modes to maintain economic vitality of the area. Some congestion due to concentration of through traffic on fringes can be anticipated. Large scale Vehicle-Free Zones require internal people movers. Providing access on a large scale by conventional bus transit or park and ride is a difficult problem in Phoenix. Considerable resistance can be anticipated from public and business interests in affected area, particularly retailers. The overall contribution of Vehicle-Free Zones to mobil source emission reduction is positive. No reduction credits resulting from this measure have been taken, as specific proposals for such zones have not been defined. However, Vehicle-Free Zones are encouraged whenever they respond to other planning goals and objectives of the community.

Work Schedule Shifts

These strategies produce elements of both flow improvements and vehicle travel reductions, but since the results are achieved through modifications in the temporal patterns of business activity rather than through a direct change in elements of the transportation system, they are treated separately.

Shifts from the conventional five-day work week to a four-day work week would produce substantial reductions in journey to work travel and, in cases where it has been tested, has proved cost effective from an employer standpoint in that it has resulted in net productivity increases. The four-day week would also result in some traffic flow improvements (with attendant marginal emission reductions) on Mondays and Fridays, if half the labor force could take their extra day off on each of these days. Improvements could be realized on each of the week-days if it were possible and acceptable to apportion the extra day off evenly.

The four-day work week measure appears to have more potential where mobile source air pollution problems are related to hot spots near employment concentrations during peak commuter periods. In Phoenix, however, where the problem is primarily regionally oriented, this approach will have less impact. This is because total travel in the region on a typical weekend day is only marginally less than that on the typical midweek day which it would effectively replace.

Another form of work schedule change is that of staggered work hours -- staggering employment starting and quitting hours. This would not produce VMT reductions but, by spreading peak traffic, would result in some flow improvements. However, since the Phoenix problem is a total all-day areawide emissions problem rather than a concentrated temporal and area problem, and because flow improvements provide only marginal emission improvements, this is not seen as a high leverage strategy.

Improved Mass Transit Service

As detailed in Appendix D, the Phoenix area is characterized by a highly dispersed, low-density pattern of development in residential as well as employment and retail activities. Concomitant with decentralized development is a highly dispersed pattern of trip origins and destinations with scant definition of common travel-desire-line corridors and little convergence of travel lines on the city center or other activity node.

Such a pattern of development and trip making is not well suited for services by the higher types of public transit service--rail rapid transit, other forums of fixed guideway systems, and conventional buses operating on exclusive grade separated rights-of-way, and linear systems are hereafter referred to generically as rapid transit. Rapid transit services are effective only when large numbers of persons can be transported along a relatively limited number of linear routes, with origins and destinations in such proximity to stations that door-to-door travel time by transit is comparable to travel time by auto. These prerequisite conditions do not exist in Phoenix today.

The conventional bus transit operation in Phoenix today is well run and has fairly extensive area coverage ,but the level of service is designed primarily to meet the basic needs of transit dependent groups rather than to achieve high levels of choice ridership. To be sure, increases in choice ridership could be achieved through provision of higher levels of service (lower headways, extended route coverage, extended hours of operations), conventional innovations (such as exclusive lanes on surface streets, freeway express service, subscription services, etc.) and cosmetic improvements (air conditioning, provision of benches and shelters at bus stops, publicity and marketing, etc.).

Reductions in VMT which can be achieved through conventional service improvements are limited, however. Even with the generous assumption that all new riders are choice riders (attracted from their autos) rather than captive riders making new trips and assuming a very low auto occupancy factor of 1.2 persons per car, a 100 percent increase in current transit ridership would result in only an approximately four-tenths of one percent (.0043) decrease in the area VMT total. An increase over current ridership which would result in a meaningful VMT decrease, say 1,000 percent is an order of magnitude change, achievable only through an order of magnitude change in level of transit service (including rapid transit operation).

Even if such transit facilities could be planned, constructed and placed in service in the time frame required for meeting the Federal air quality standards, which they cannot be, the character of the Phoenix area, as discussed above, is unsuitable for their effective operation.

One new form of transit operation has proven effective in a limited number of cities for servicing low density development. This concept of flexible-routed, demand-actuated transit service is popularly called Dial-a-Bus or Dial-a-Ride. In the limited number of communities in which it is in operation, Dial-a-Ride has proven a highly attractive form of transit service. But it's potential for large scale contribution to area-wide VMT, hence emission, reduction in Phoenix is limited by the fact that to be effective, the flexibly-routed, demand-actuated service must be limited to small, defined service domains. Thus, a typical work trip of about six miles might have to transfer between two or three Dial-a-Buses or to a fixed route and then another Dial-a-Bus to complete the journey, with patronage strongly discouraged by each transfer required. The principal vehicle trips which would be replaced by diversion to Dial-a-Ride would be short range trips which within the localized domain of a single Dial-a-Ride operation. Despite the fact that VMT reductions which might result from such operations appear low and no credit is taken for them herein, Dial-a-Ride operations are encouraged where they coincide with other community policy and planning goals and objectives.

Jitney service is a long-standing form of transit operation which has been proposed in several cities as a measure for attracting transit ridership and reducing auto traffic and emissions. It is essentially a shared-taxi service operating along a basic fixed route with small diversions possible and current operations in intense activity corridors in the larger cities attract high patronage. However, a number of factors limit the potential for this service as a control measure for the Phoenix air quality problem:

- There are few, if any, corridors in Phoenix having activity concentrations sufficient to support Jitney operation.
- A high percentage of typical Jitney riders are diverted from pedestrian rather than auto mode. Those who are diverted from autos are typically making very short trips so actual VMT reduction per passenger carried is low.
- Jitney reduction contributions might be identifiable in a heavily travelled corridor with hotspot concentrations of pollutants. But in Phoenix, where the problem is area-wide, potential reduction contribution due to Jitney operation is too small to quantify.

Pricing Schemes

Schemes to reduce VMT through gasoline pricing techniques are highly ineffective and heavily regressive. The average American spends 9 percent of his income on transportation and although elasticies of gasoline cost are not well defined, even major increases, perhaps doubling the price, do not appear likely to affect consumption. This is borne out by the staggering increases in European auto travel with fuel costs double those in the U.S.

Pricing auto ownership is similarly ineffective. Auto owners have a fixed investment in their current vehicles and are unlikely to dispose of them. When purchasing new vehicles they would simply buy a cheaper model new or older used car than they might otherwise purchase. Pricing schemes are indiscriminately imposed on all segments of society but the impact, those who are priced off the road, falls on limited income groups.

Moratorium on Traffic Improvements

Several factors mitigate against schemes to reduce VMT by permitting traffic service conditions to decay, thereby encouraging shifts to transit or discouraging auto trips from being made at all. Although exclusive bus lanes may be provided in some areas, conventional transit service must generally operate on the same streets as the autos and would also be negatively impacted. Experience in most U.S. cities confirms the motorists' dogged determinination to drive in spite of seemingly intolerable levels of congestion. And added, to the safety compromise which would be implied by a moratorium on traffic improvements is the fact that going from VMT reductions due to shifts to transit would be outweighed by pollution increases due to increased auto operations in the low-speed, high-emission range.

New Freeway Construction

New freeway construction appears to offer positive but limited contribution to reduction of mobile source emissions over the period of concern in this study. Even if all 26 miles of I-10 construction currently programmed for the period were to be completed and serving an average daily traffic of 50,000 on each mile by 1977, the net change in area-wide average travel speed would be less than two miles per hour. Most of the speed increases would come in speed ranges within which the payoff in terms of emission reductions is quite marginal. Thus, while new freeway construction's contribution to the area-wide air pollution problem is evaluated as positive, no reduction credit has been taken because of the marginal nature of the contribution and the high level of uncertainty that all or any of the proposed construction will be completed and in use by 1977.

The above analysis is not intended as a blanket endorsement of the freeway program in the Phoenix area. Experience over the past 20 years in cities nation-wide gives some indication that the dramatic changes in accessibility which result with opening of new freeways tend to induce new and longer vehicle trip making, accelerating the VMT growth rate and lending further support to a dispersed pattern of development not well served by public transit, resulting in continued dependence on the automobile. These impacts, however, are long term in nature, not well defined, and are not of concern in the immediate study time frame. However, any overall evaluation of the freeway program must investigate possible negative long-term impacts on air quality as well as the positive impacts which have been identified herein.

Moreover, the analyses herein have been based on area-wide air quality considerations. Planning of each individual element of the freeway system should include careful evaluation of positive and negative effects on air quality in the travel corridor affected.

PROPOSED CONTROL STRATEGY

The proposed transportation control strategy developed for the Phoenix area consists of two phases. Phase I is designed to accomplish substantial improvements in air quality for the 1975 through 1980 period. Based on an analysis of current data (1969), however, additional controls may be necessary. Consequently, a Phase II program has been formulated in order to insure compliance with the standards. The need for implementing Phase II should be based on the results obtained from Phase I. The measures associated with both phases of the proposed transportation control strategy are listed below:

Phase I

- Improved air quality surveillance system
- Mandatory vehicle inspection/maintenance for all vehicles
- Retrofit emission control for all pre-1968 vehicles
- Evaporative emission control

Phase II (if necessary)

- Vehicle exchange program
- Limited second vehicle registration

A brief description of each measure is presented in the following.

Air Quality Surveillance System

The surveillance system proposed by this plan uses the existing system and the system recommended by the Arizona State Implementation Plan as a foundation for developing the capability for monitoring Set II pollutants in the Phoenix-Tucson problem area. The recommendations in this plan consist mostly of expanding the use of CO and O_x monitors through the metropolitan area to provide for reasonable accuracy in evaluating peaks and trends in air quality and in assessing the effectiveness of the implementation plan. It has been found that sites used or proposed prior to this plan can generally be used and that they provide an effective distribution of monitors. The approximate cost of equipment for the system proposed in this plan is $24,000 to $33,000. In addition, the MCHD mobile lab is regarded as a highly useful means of determining the spread of pollutant concentration and of identifying the need for longer-term monitoring and source control.

Mandatory Vehicle Inspection/Maintenance

One of the key components of the transportation control study involves a mandatory program of vehicle inspection/maintenance. Such a program will yield not only moderate emission reductions from the present vehicle fleet, but will also insure the proper operation of advanced control systems as they are introduced into the automobile population. It is this second factor that, in the long run, will have the largest impact on air quality. The state of Arizona recently passed legislation for a three-phased inspection/maintenance program. Funds have been allocated, approximately one million dollars, for the construction and testing of a prototype system. Results from this phase will determine the shape of the full program (to be completed by 1975).

Current studies indicate that the most cost-effective program involves a yearly exhaust emission inspection under load, followed as necessary by the adjustment and/or repair of the following engine components: idle air/fuel ratio, ignition system (misfire), air cleaner, and PCV valve. Pass/fail exhaust emission criteria should be established to obtain the necessary reductions. A rejection rate of 30 to 40 percent may be required for the first year. The program should include a certification of service garages involved to insure reliable maintenance repair. Any retest of emissions after maintenance should be made optional. Extreme care should be taken to insure consistency in testing between the various state lanes. Estimates of potential emission reductions for the total population are 12 percent for hydrocarbons, 10 percent for carbon monoxide, and 0 percent for oxides of nitrogen. These reductions can be achieved for an annual cost of between $5 and $15 per car.

Retrofit Emission Control

The second recommended control measure consists of retrofitting the pre-1968 portion of the vehicle population. Basically, there are two retrofit approaches that are suitable for use in the Phoenix metropolitan area. The first one -- Vacuum Spark Advance Disconnect (VSAD) -- is particularly attractive for use on older vehicles in terms of potential emission reduction, cost, reliability and ease of implementation. Costs, including labor and a simple override mechanism, should be from $15 to $30. Some deterioration in fuel economy and driveability will occur on the average.

The other retrofit approach -- Lean Idle Setting (LIS) -- has good possibilities except for a high probability of owner or mechanic tampering. This procedure involves the additional leaning out of the air/fuel ratio beyond the manufacturer's specification. The cost per adjustment should be nominal - $3 to $6 - and fuel economy should improve slightly on the average. This modification is theoretically simple, but present mechanic ability and instrumentation limitations indicate the need for substantial improvement.

The combined emission reduction potential for both retrofit devices was computed as 25 percent for HC, 9 percent for CO, and 28 percent for NO_x. Again, this is consistent with current EPA estimates. In order to insure proper operation of these two systems, especially LIS, it is suggested that both be incorporated into the annual inspection program.

Evaporative Emission Control

The third element of the transportation plan calls for the control of evaporative losses. Vehicle operation (carburetor and gas tank) and gasoline marketing (gas tank and storage tank filling) represent the two main sources of Hydrocarbon (HC) evaporative losses in the Phoenix area. For controlling losses from the in use fleet (pre-1971), it is recommended that the Reid Vapor Pressure for all gasoline marketed in the Phoenix area be controlled seasonally. This should yield over a 30 percent reduction in losses [23, 24] with moderate impact (approximately 1-2¢ per gallon on overall marketing operations [7,32]. Some driveability problems may occur during start-up, although they should be of a minimal nature [23].

Several methods are available for controlling evaporative losses from gasoline marketing. These include an adaptive pump nozzle, absorber or condenser system, and/or a vapor return and recovery system. Approximately 70 percent of the vehicles on the road (mostly domestic) can be serviced from one adaptive pump nozzle. The average costs of equipping service stations in the Phoenix area with evaporative recovery systems should run about $2000 per station.

Developmental and distribution problems may limit the availability of this type of equipment for the near term. The economic impact of this control approach should be further investigated.

Vehicle Exchange Program

All things considered, older vehicles (pre-1968) emit higher emissions per mile than do later model automobiles. The Vehicle Exchange Program is designed to take advantage of this situation by limiting the importation of pre-1968 vehicles and by replacing some of the older vintage cards with newer, lower emitting vehicles. Considerations should be given to limiting out-of-state vehicle registration for pre-1968 cars after 31 December 1973. This would have the effect of reducing the aggregate exhaust emissions by about three percent.

Coupled with this would be a program to replace a segment of the older in use cars with newer state and local government vehicles. One phase of this program would be to increase the rate of turnover of state owned vehicles to around 50 percent per year. Based on the current size of the state fleet, approximately 5000 cars would be available for exchange with pre-1968 vehicles on a yearly basis.

Criteria for exchange would have to be developed in order to maximize program effectiveness (including income considerations). This combined program would be of short-term value, since by 1980 only about three percent of the vehicle population will consist of pre-1968 automobiles. The administrative costs of this program should only add a small increment to ongoing registration costs. However, the costs associated with exchanging these vehicles may be on the order of several million additional dollars annually.

The net effect of both programs in terms of emission reduction potential should be around six percent.

Limited Second Vehicle Registration

A preliminary assessment of the impact of the foregoing measures on air quality indicates the potential need for additional vehicle control. Specifically, it appears that approximately a thirty percent reduction in vehicle miles traveled (VMT) (implying a need for an additional thirty percent quality improvement) may be required to achieve the national standards. The uncertainty in this estimate is closely related to the uncertainty in the baseline emissions data and limitations in the method used for predicting future air quality.

One approach for ensuring such a reduction in VMT is by restricting the use of second and third family cars. This could be accomplished through the registration process, but the details and implications of a specific program would have to be very carefully assessed in terms of the political, institutional, legal and socio-economic impact on the Phoenix area. One positive benefit of such a program would be more efficient use of the family's primary vehicle, which in turn, would tend to encourage car pooling and some additional use of the mass transit system. Variances on this moratorium could be granted if the vehicle were converted to operate on gaseous fuels.

Impact of Proposed Strategy

The impact of these control measures taken singularly and collectively on air quality is presented in Tables 8 through 10 for CO (8 hour maximum), NO_2 and O_x, respectively. These results were developed using the air quality model (see Appendix G). The CO levels were forecasted using confirmed maximum values for 1969. The effect of these measures on the various pollutants is dramatic. For example, the Evaporative Emission Control Program has no impact on CO, but has a substantial effect on photochemical oxidants. Few, if any, of the vehicular oriented measures have a major effect on CO. This is due primarily to the lack of cost-effective measures for controlling CO. Oxidizing catalysts for the in use fleet offer high potential reductions (maybe 50 percent) for CO; however, the costs of these units may exceed the market value of the car.

These results also reveal the impact of time on air quantity concentrations. Specifically, the forecasted CO level is 16 mg/m^3 by 1975 and 9 mg/m^3 by 1980. This nearly 50 percent reduction in concentration can be attributed to both the Federal New Car Program and the proposed Transportation Control Strategy. The forecasted concentration levels for NO_2 and O_x, although less dramatic, show similar trends.

Table 8. Impact of Proposed Control Strategy
on Future Phoenix Air Quality

Pollutant: Carbon Monoxide (8 hour maximum) MG/M^3

Measure	Time 1975	1977	1978	1980
1. Baseline	25	20	18	14
2. Inspection/Maintenance Program (with #1)	24	19	17	14
3. Retrofit Program (with #2)	23	18	16	13
4. Evaporative Loss Program (with #3)	23	18	16	13
5. Vehicle Exchange Program (with #4)	22	17	15	12
6. Limited Registration Program (with #5)	16	11	10	9

NOTE: The values in this Table were forecasted using the air quality model described in Appendix G.

Table 9. Impact of Proposed Control Strategy on Future Phoenix Air Quality

Pollutant: Oxides of Nitrogen (Annual) $\mu G/M^3$

Measure	Time			
	1975	1977	1978	1980
1. Baseline	254	277	214	208
2. Inspection/Maintenance Program (with #1)	254	227	214	208
3. Retrofit Program (with #2)	252	225	213	208
4. Evaporative Loss Program (with #3)	252	225	213	208
5. Vehicle Exchange Program (with #4)	255	227	216	209
6. Limited Registration Program (with #5)	213	191	181	178

NOTE: The values in this Table were forecasted using the air quality model described in Appendix G.

Table 10. Impact of Proposed Control Strategy
on Future Phoenix Air Quality

Pollutant: Photochemical Oxidants (1 hour maximum) $\mu G/M^3$

Measure	Time 1975	1977	1978	1980
1. Baseline	233	226	224	219
2. Inspection/Maintenance Program (with #1)	231	225	222	214
3. Retrofit Program (with #2)	229	224	219	213
4. Evaporative Loss Program (with #3)	211	187	180	170
5. Vehicle Exchange Program (with #4)	211	184	176	168
6. Limited Registration Program (with #5)	165	148	144	139

NOTE: The values in this Table were forecasted using the air quality model described in Appendix G.

Obstacles to Implementation

The relative significance of obstacles to implementation of the proposed transportation control strategy has been estimated using the following categories:

Technical obstacles - obstacles involving the design of hardware, details of administrative procedure, or specification of standards or acceptance limits necessary for implementing recommended control measures.

Political obstacles - obstacles involving the feasibility of productive interaction among appropriate leaders, administrators, legislators, and special interest groups for the purpose of instituting recommended control measures.

Legal/institutional obstacles - obstacles involving writing and passing laws, rules, and regulations required for instituting and administering control measures.

Socio-economic obstacles - obstacles involving the impact of control measures on the public, commerce, and industry.

In general, there appear to be few significant obstacles that would limit the implementation for the first three control measures. Mandatory inspection/maintenance may encounter a few moderate political obstacles depending on the eventual shape of the proposed parts of the program. These obstacles are not expected to be major, since the program has so far had good public acceptance and generally good political acceptance.

Socio-economic obstacles to the implementation of retrofit emission control should be of moderate significance, at most. According to the citizen survey results done in connection with the Phoenix-Tucson plan (see Appendix H), the public will generally accept the cost of this program. There will be some moderate adjustments necessary in local commerce to provide for supplying retrofit devices.

Evaporative emission control should meet only minor legislative and socio-economic obstacles. Necessary laws and regulations are easily specified since there is a large backlog of feasibility studies and investigations involving this measure, and since at least one local agency in the country has already instituted requirements for a similar measure and can serve as a model. There should be very little socio-economic impact due to this measure. The cost of changes in gasoline refining and marketing will indeed be passed on to the consumer, but the actual cost increase per gallon should be small. Public convenience and vehicle driveability should barely be affected at all; consequently, minimal public reaction is expected in these areas. Moderate technical obstacles will appear in the forms of hardware development and design for gasoline marketing control systems and of refinery processes and operation changes required to reduce the RVP of gasoline. These technical obstacles will fall generally within the realm of the oil companies which supply Phoenix with gasoline, since it will be their responsibility to select technical means for meeting standards for gasoline handling loss control and RVP. It is expected that their reaction to the proposal for the evaporative emission control measure will present a moderate political obstacle to implementation.

The last two measures should encounter obstacles of major significance in the categories of socio-economics and politics. It is expected that these two programs -- vehicle exchange and limited vehicle registration -- will be the most controversial and will encounter the greatest amounts of debate, regarding public acceptance and political feasibility, of all measures proposed. One of the largest obstacles to implementation of the vehicle exchange program is the possibly unpopular implication of social programs associated with this measure. For this reason, its implementation must be carefully planned to insure equitable distribution of exchanged vehicles, and this equity must be visible to the public to minimize socio-economic and political impact. The funding for fleet vehicle purchase presents another major obstacle to implementation, although, as a result of preliminary investigation, it seems possible that the Federal Revenue Sharing Program may indirectly provide assistance by providing local governments with funds which can be used to replace fleet vehicles. Authorizing legislation and the technical details and mechanics of the actual exchange of vehicles represent moderately sensitive issues.

The limited vehicle registration program may encounter major legislative, socio-economic, and political obstacles and moderate technical obstacles. Laws will be necessary to authorize the State Highway Department to administer such a program, and regulations must be adopted which will dictate exactly what categories of vehicles may not be registered. Such legislation may significantly impact the socio-economic and political arenas. The public will very likely view this measure as a serious infringement on personal freedom, and it may have virtual ill effects on convenience and on family budgets (although the actual effect should be more efficient use of transportation and resultant decrease in family costs).

CONTROL STRATEGY IMPLEMENTATION

Included in the following section are the recommendations concerning the schedule for implementation and legislative, procedural, and administrative requirements for implementation of the transportation control strategy. The actual implementation of this or other related strategies will depend heavily on Federal assistance. This is especially the case for the inspection/maintenance and vehicle exchange programs. Furthermore, the limited time available for achieving the air quality standards will require maximum cooperation between the State of Arizona and the EPA.

PROCEDURE AND TIME SCHEDULE

The schedule for plan implementation is shown in Table 10 . The table is generally self-explanatory. It assumes acceptance of the proposed plan and indicates dates for plan completion, approval, and necessary legislation. The pollution control measures are listed separately and dates for their implementation are indicated. The following are highlights of the implementation schedule:

(1.) Additions to the air quality surveillance system are to be installed by August 1974, provided that sufficient EDA funding is available. These are discussed later in this report.

(2.) Traffic system improvements have already been implemented and are ongoing. The traffic surveillance system should be completed by 1 January 1975 and is discussed later in this report.

(3.) The I/M Program schedule is shown as planned by the ASHD. This schedule is discussed later in this document.

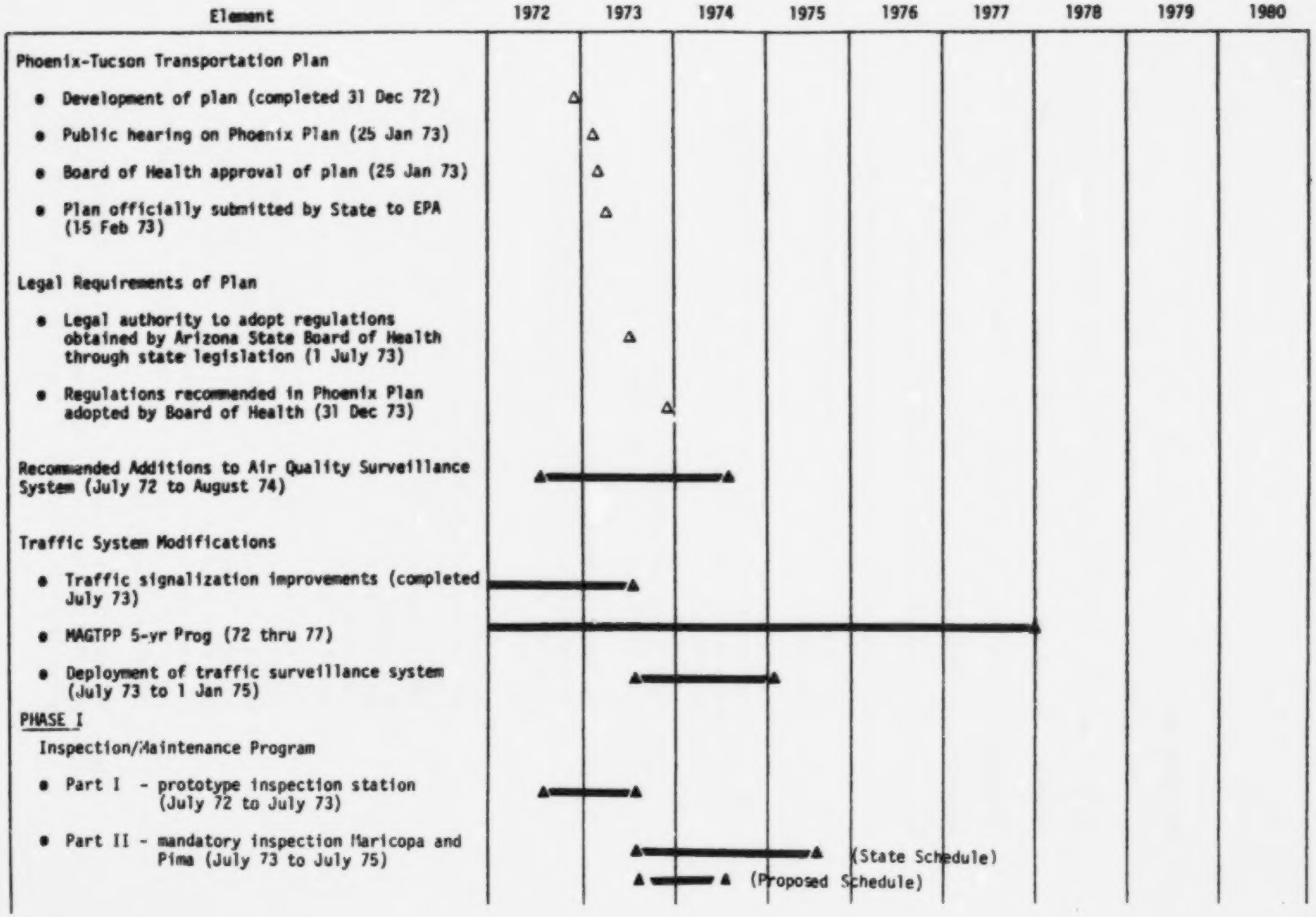
(4.) The Retrofit Program will require one year and should be completed by July 1974. This date allows for the solution, before 1975, of unforeseen problems which may occur.

(5.) New gasoline filling stations and bulk storage terminals will be required to have evaporative control systems by 1 January 1974. Stations existing before that time must submit compliance schedules by 1 July 1974 and must comply by 1 January 1975. Thus, over one year from the present date is provided for oil company evaluation of currently available control systems or for the final development of current prototype systems.

The reduction in the gasoline RVP standard will become effective 1 July 1974. This allows several summer months for verification by ASHD that gasoline piped to and sold in Phoenix does indeed meet this new standard. This also means that refineries supplying Phoenix (most of these are in Texas and California) have over a year and a half to make process changes necessary for reducing the RVP of the product.

(6.) If Phase II is necessary, funds should be appropriated in mid-1974 for the vehicle exchange program. Exchange will actually begin 1 January 1975 and continue through 1980.

Table 11. PROPOSED IMPLEMENTATION SCHEDULE



Phoenix-Tucson Transportation Plan

- Development of plan (completed 31 Dec 72)
- Public hearing on Phoenix Plan (25 Jan 73)
- Board of Health approval of plan (25 Jan 73)
- Plan officially submitted by State to EPA (15 Feb 73)

Legal Requirements of Plan

- Legal authority to adopt regulations obtained by Arizona State Board of Health through state legislation (1 July 73)
- Regulations recommended in Phoenix Plan adopted by Board of Health (31 Dec 73)

Recommended Additions to Air Quality Surveillance System (July 72 to August 74)

Traffic System Modifications

- Traffic signalization improvements (completed July 73)
- MAGTPP 5-yr Prog (72 thru 77)
- Deployment of traffic surveillance system (July 73 to 1 Jan 75)

PHASE I

Inspection/Maintenance Program

- Part I - prototype inspection station (July 72 to July 73)
- Part II - mandatory inspection Maricopa and Pima (July 73 to July 75)

Table 11. PROPOSED IMPLEMENTATION SCHEDULE (Continued)

Element

Inspection/Maintenance Program (Continued)

- Part III - mandatory inspection statewide (beginning July 75)

Retrofit of Pre-1968 Vehicles (lean idle setting & vacuum spark advance disconnect) (July 73 to July 74)

Gasoline Evaporative Loss Control

- Evaporative control systems required on new major gasoline marketing facilities (starting 1 Jan 74)
- Compliance schedule required from gasoline marketing facilities in existence before 1 Jan 74 (1 July 73)
- Final date for compliance of gasoline marketing facilities (1 Jan 75)
- Maximum gasoline RVP standard reduced to 7 PSI (effective 1 July 74)

PHASE II (If Necessary)

Vehicle Exchange Program

- Funds appropriated by Arizona & Phoenix to replace fleet vehicles (1 July 74)
- Yearly exchange of fleet vehicles for private pre-1968 vehicles and subsequent deportation of pre-1968 vehicles (effective 1 Jan 75)

Limited Vehicle Registration Program

- No pre-1968 vehicles from out of state allowed to be registered in Arizona (beginning 1 Jan 75)

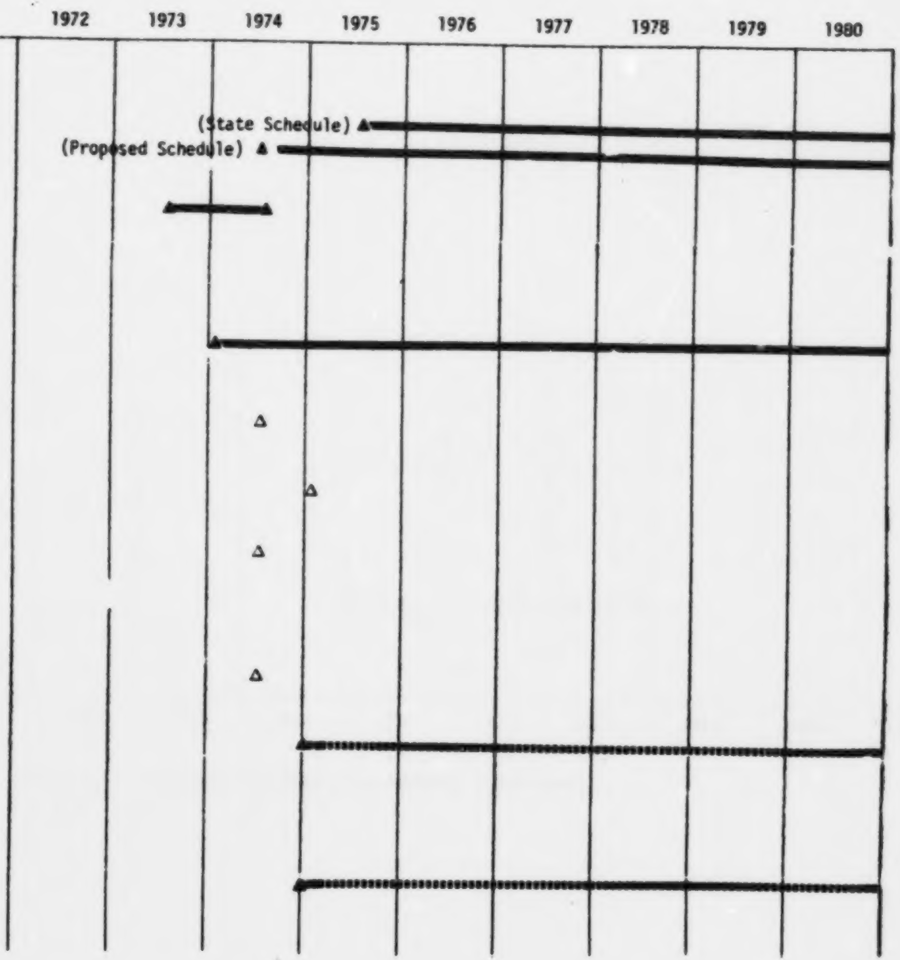
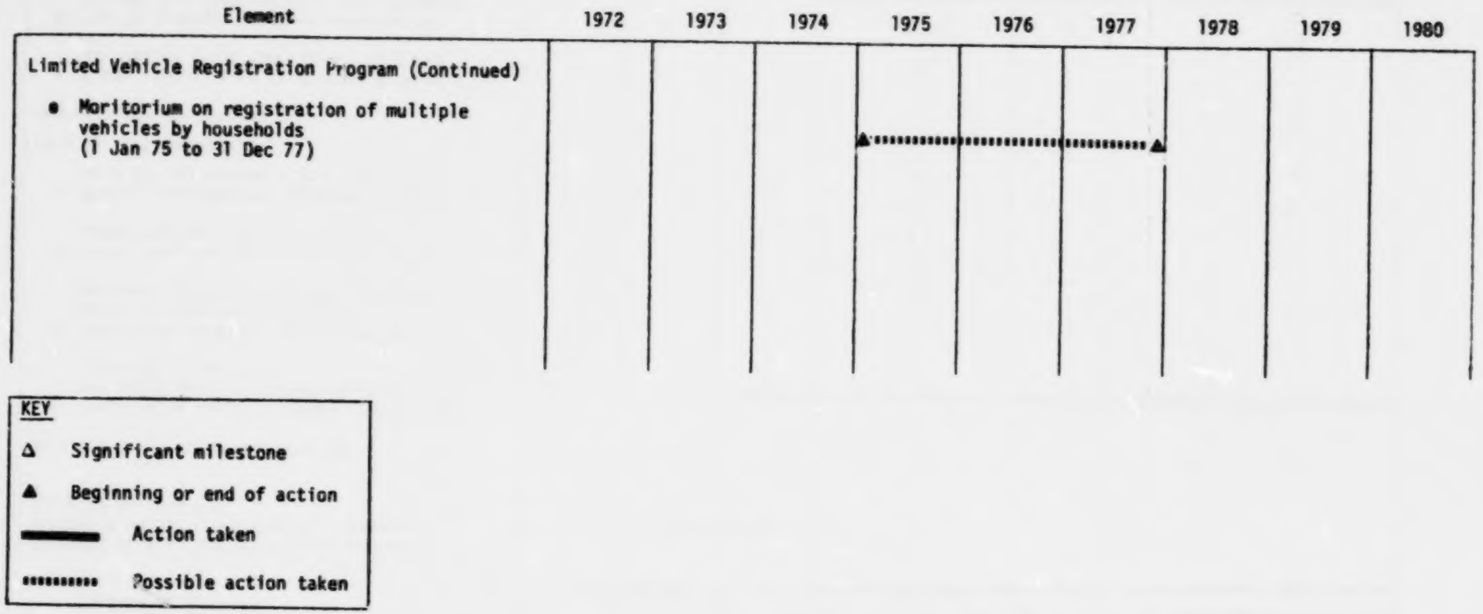


Table 11. PROPOSED IMPLEMENTATION SCHEDULE (Continued)



(7.) The two limited vehicle registration measures, if necessary, should go into effect with 1975 registration, at the first of the year. This date allows two years for determining, from close observation of air quality, whether these measures are necessary.

AGENCY INVOLVEMENT

It is recommended that the Arizona State Department of Health, Division of Air Pollution Control, be responsible for the general administration of the Phoenix-Tucson Transportation Control Strategy (see Figure 10).

The State Department of Health should have supra-management responsibility for the following:

1. Administration of contract and grant programs related to the transportation control strategy.
2. Coordination of air pollution control programs which involve multi-county areas.
3. Representation of Arizona in finding solutions to Set II pollutant problems which extend across state boundaries.

The department should have power to appoint task force teams selected from local agencies to aid and advise the department regarding studies and programs specific to certain areas of Arizona (such as air quality control regions, counties, and towns). The department should focus air pollution control administration and should act as an integrator and coordinator in ensuring the efficient development and implementation of the air pollution control programs.

Agency responsibility with regard to the specific programs in the control strategy is described in Table 12. The Arizona State Health

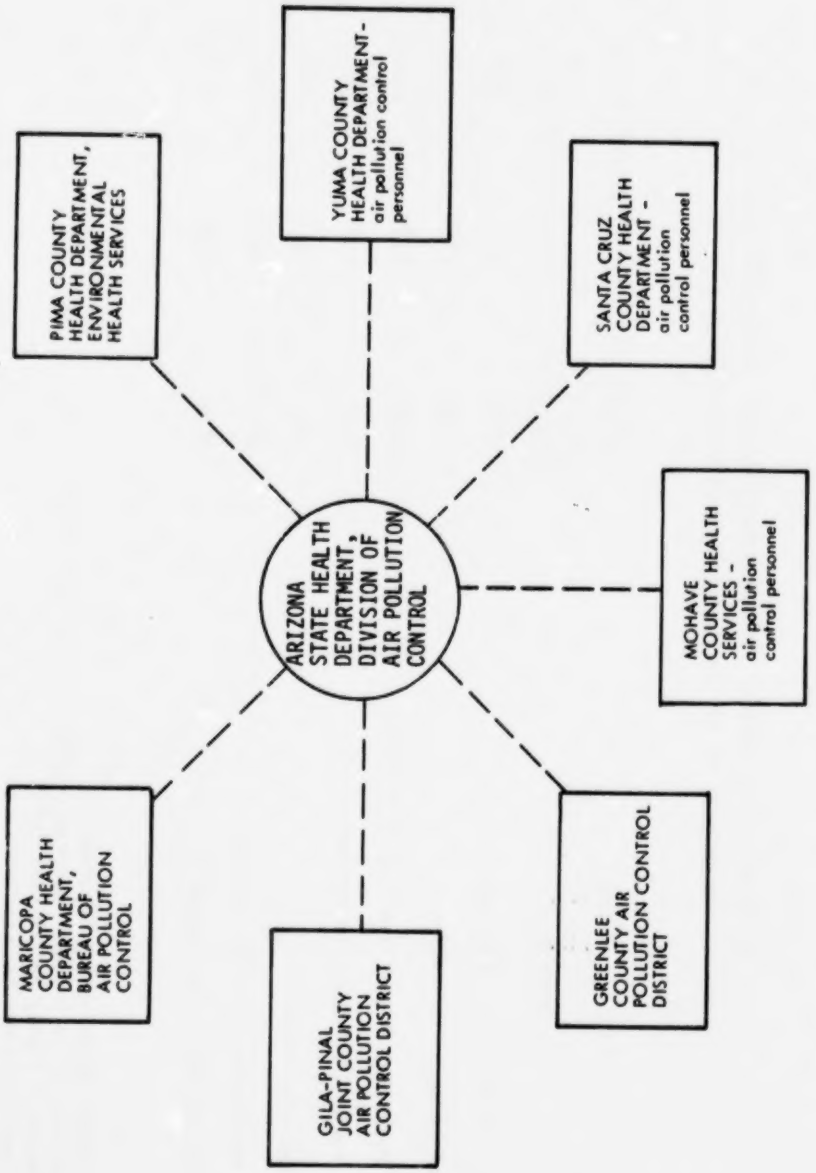

ARIZONA STATE HEALTH DEPARTMENT, DIVISION OF AIR POLLUTION CONTROL
PIMA COUNTY HEALTH DEPARTMENT, ENVIRONMENTAL HEALTH SERVICES
YUMA COUNTY HEALTH DEPARTMENT- air pollution control personnel
SANTA CRUZ COUNTY HEALTH DEPARTMENT - air pollution control personnel
MOHAVE COUNTY HEALTH SERVICES - air pollution control personnel
GREENLEE COUNTY AIR POLLUTION CONTROL DISTRICT
GILA-PINAL JOINT COUNTY AIR POLLUTION CONTROL DISTRICT
MARICOPA COUNTY HEALTH DEPARTMENT, BUREAU OF AIR POLLUTION CONTROL

Figure 10. Proposed Air Quality Management Organization

Table 12. AGENCIES RESPONSIBLE FOR THE ADMINISTRATION, MONITORING AND ENFORCEMENT OF THE PROPOSED TRANSPORTATION CONTROL STRATEGY

Air Control Board	Geographical Area of Responsibility		
Program	City of Phoenix	Maricopa County	Pima County
Motor Vehicle Emission Inspection Program	ASHD	ASHD	ASHD
Motor Vehicle Retrofit Program	ASHD	ASHD	ASHD
Gasoline Marketing Evaporative Control Program	MCHD	MCHD	PCHD
Gasoline Maximum RVP Standard Program	ASHD	ASHD	ASHD
Vehicle Exchange Program	MVD	MVD	MVD
Limited Vehicle Registration Program	MVD	MVD	MVD
Air Quality Surveillance Program	MCHD	MCHD	PCHD

ASHD: Arizona State Health Department
MVD: Arizona State Highway Department (Motor Vehicle Division)
MCHD: Maricopa County Health Department
PCHD: Pima County Health Department

Department has responsibility for administering, monitoring, and enforcing the inspection program, the retrofit program, and the gasoline maximum RVP standard program in both Maricopa and Pima counties. The Motor Vehicle Division of the Arizona State Highway Department is responsible for vehicle exchange and for limiting vehicle registration. Air quality surveillance and the administration and enforcement of the Gasoline Marketing Evaporative Control Program are the responsibility of the County Health Departments in Maricopa and Pima counties, respectively.

LEGAL AUTHORITY

Authorizing legislation for the Air Quality Surveillance Program and each control measure is indicated on Table 13. The entries in the column labeled "Federal Regulation" refer to subsections of environmental regulations developed by EPA for implementation planning. The other two columns quote statutes in the State of Arizona Air Pollution Control Laws which provide legislative authority for state and local agencies, respectively.

Table 13. LEGAL AUTHORITY FOR IMPLEMENTATION OF THE PROPOSED TRANSPORTATION CONTROL STRATEGY

Air Control Board

Program	Authorizing Legislation		
	Federal Regulation	State Statute Section	Local (County) Statute Section
Motor Vehicle Emission Inspection Program	420.11 (b)(1)	36-1717B.	----
Motor Vehicle Retrofit Program	420.11 (a)(5)	36-1717C. 36-1717D.	----
Gasoline Evaporative Emission Control Program	420.11 (a)(5)	----	36-779 thru -788
Gasoline Maximum RVP Standard Program	420.11 (a)(2)	36-1707A. 36-1717E.	----
Vehicle Exchange Program	----	TBL	----
Limited Vehicle Registration Program		TBL	----
Air Quality Surveillance Program	----		36-773 36-774

TBL: To be legislated

IMPLEMENTATION SURVEILLANCE

Air Quality

Table 14 summarizes the proposed air quality surveillance system for Phoenix and suburbs of Phoenix. This table includes descriptions of the following (for Set II Pollutants):

1) Existing sampling sites
2) Sampling sites recommended by the Arizona State Implementation Plan (ASIP)
3) Sampling sites recommended by the Transportation Control Strategy

Information from 1) and 2) comes directly from the ASIP and from contact with ASHD and MCHD personnel (Contact Report E-3). The strategy endorses the ASIP recommendations and, using 1) and 2) as a foundation, proposes an augmented system which will satisfy surveillance requirements for transportation pollution control strategies as determined in this study. The implementation of this augmented system will depend heavily on the availability of federal financial assistance.

Installation of continuous CO and 0_x monitors is recommended at the following stations (station designation numbers are parenthesized after each station name):

South Phoenix	(2)
West Phoenix	(3)
Sunnyslope	(4)
Scottsdale	(6)

All four 0_x monitors should be installed by the end of April 1973, and the CO monitors should be installed by the end of August 1973. This staggered timetable will provide for measurement of 0_x and CO during the seasons, starting with 1973, in which they typically reach peak concentrations and, at the same time, will create less budgetary strain than a single

Table 14. EXISTING AND PROPOSED AIR QUALITY SURVEILLANCE NETWORK

Designation	Address	UTM CO-ORDS		Agency Maintaining Site	Pollutant	Means of Sampling and Analysis	Status
		X	Y				
MCHD (1)	1825 E. Roosevelt, Phoenix	403.4	3702.6	MCHD	CO	Beckman NDIR, Continuous	Currently being used
				MCHD	NO_2	Jacobs-Hochheiser (NASN) 24-Hr Bubbler, every 12 days	Currently being used
				MCHD	NO_2	Beckman K-76, Continuous	Currently being used
				MCHD	O_x	Beckman Colorimetric, Continuous	Currently being used
				MCHD	Total HC	Beckman Flame Ionization, Continuous	Currently being used
South Phoenix (2)	30 W. Corona	400.5	3696.9	MCHD	CO	NDIR, Continuous	Strategy recommended installation Aug 1973
				MCHD	O_x	Chemiluminescence, Continuous	Strategy recommended installation Apr 1973
West Phoenix (3)	47th Ave. and Osborn	392.7	3705.5	MCHD	CO	MSA NDIR, Continuous	Temporary station used during summer 1971
				MCHD	O_x	Bendix Chemiluminescence, Continuous	(same as above)
				MCHD	NO_2	Jacobs-Hochheiser 24-Hr Bubbler, every 6 days	ASIP recommended installation July 1972, not yet operative
				MCHD	CO	NDIR, Continuous	Strategy recommended installation Aug 1973
				MCHD	O_x	Chemiluminescence, Continuous	Strategy recommended installation Apr 1973

Table 14. EXISTING AND PROPOSED AIR QUALITY SURVEILLANCE NETWORK (Continued)

Designation	Address	UTM X	CO-ORDS Y	Agency Maintaining Site	Pollutant	Means of Sampling and Analysis	Status
Sunnyslope (4)	8531 N. 6th St.	401.1	3713.2	MCHD	NO_2	24-Hr Bubbler, every 6 days	ASIP recommended installation May 1974
				MCHD	CO	NDIR, Continuous	Strategy recommended installation Aug 1973
				MCHD	O_x	Chemiluminescence, Continuous	Strategy recommended installation Apr 1973
Paradise Valley (5)	36th and Sweetwater	406.5	3717.8	MCHD	CO	Beckman NDIR, Continuous	ASIP recommended installation May 1973
				MCHD	O_x	Chemiluminescence, Continuous	Strategy conditionally recommended installation April 1974
Scottsdale (6)	315 E. 2nd St.	413.8	3705.9	MCHD	NO_2	24-Hr Bubbler, every 6 days	ASIP recommendation installation July 1973
				MCHD	CO	NDIR, Continuous	Strategy recommended installation Aug 1973
				MCHD	O_x	Chemiluminescence, Continuous	Strategy recommended installation Apr 1973
GM Proving Phoenix (7)	1330 S. Ellsworth	439.7	3689.9	MCHD	NO_2	24-Hr Bubbler, every 6 days	ASIP recommendation installation Dec 1972
				MCHD	CO	NDIR, Continuous	Strategy conditionally recommended installation Apr 1974
				MCHD	O_x	Chemiluminescence, Continuous	Strategy conditionally recommended installation Apr 1974

Table 14. EXISTING AND PROPOSED AIR QUALITY SURVEILLANCE NETWORK (Continued)

Designation	Address	UTM X	CO-ORDS Y	Agency Maintaining Site	Pollutant	Means of Sampling and Analysis	Status
Downtown Phoenix (37)	(To be determined)	400±3	3701±3	MCHD	NO_2	24-Hr Bubbler, every 6 days	ASIP recommended installation July 1972
				MCHD	CO	Mobile Lab	Strategy recommended sampling Aug thru Apr
				MCHD	O_x	Mobile Lab	Strategy recommended sampling Apr thru Aug
				MCHD	NC	Mobile Lab	Strategy recommended sampling Apr thru Aug

NOTES

ASIP: Arizona State Implementation Plan

Strategy: Transportation Control Strategy for the Phoenix-Tucson Air Quality Area

Outlined areas are strategy recommendations step-function investment. The approximate cost for equipment acquisition and installation for all four of these sites is $24,000 (see Table 15).

The strategy has been based on data from samples taken at MCHD (1) in 1969. It has been assumed, for the purpose of this study, that this data is representative of worst-case air quality in Phoenix. However, because of Phoenix's relatively broad population and traffic distributions, it is not unlikely that other areas of the city experience consistently worse air quality than the area sampled by the MCHD (1) station. Furthermore, the sample intake for MCHD (1) analyzers is over 30 feet from ground level (Contact Report E-3 .). This accomplishes MCHD's objective in eliminating readout "noise" for better long-term analysis, but it may allow high concentrations of pollutants (especially CO, which is emitted near ground level) to be overlooked in areas of the city experiencing high traffic density.

The Phoenix map (Figure 11) indicates that these four recommended sites are evenly distributed through the Phoenix metropolitan area. In addition, they are in close proximity to areas of Paradise Valley, Scottsdale, South Phoenix, and West Phoenix which are prone to traffic bottleneck formation. Data from these four sites and the MCHD (1) site will provide necessary information for monitoring strategy progress in improving air quality.

The strategy conditionally recommends installation of a continuous O_x analyzer at Paradise Valley (5) and conditionally recommends installation of continuous CO and O_x analyzers at the GM Proving Grounds (7), both in 1974. The condition upon which these recommendations are based is that air quality in consecutive years degrade significantly as

Table 15. CAPITAL COST OF ADDITIONS TO AIR QUALITY SURVEILLANCE SYSTEM RECOMMENDED BY THE TRANSPORTATION CONTROL STRATEGY

PTTP Recommended Site	Approximate Capital Cost	Year of Installation
South Phoenix (2)	$6000.	1973
West Phoenix (3)	$6000.	1973
Sunnyslope (4)	$6000.	1973
Paradise Valley (5) (Conditional)	$3000.	1974
Scottsdale (6)	$6000.	1973
GM Proving Grounds (7) (Conditional)	$6000.	1974
Downtown Phoenix (37)	--	--
1973 Total	$24000.	
1974 Conditional Total	$9000.	
Grand Total	$24000. to $33000.	

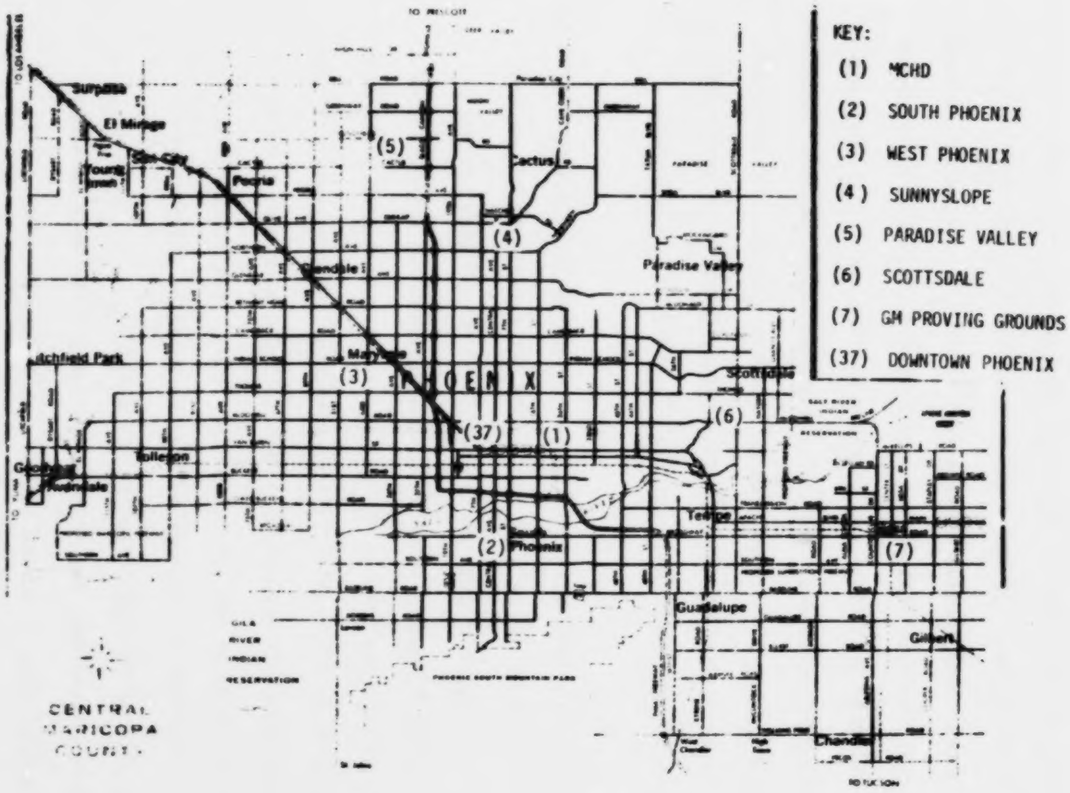

KEY:
(1) MCHD
(2) SOUTH PHOENIX
(3) WEST PHOENIX
(4) SUNNYSLOPE
(5) PARADISE VALLEY
(6) SCOTTSDALE
(7) GM PROVING GROUNDS
(37) DOWNTOWN PHOENIX
Surprise
El Mirage
Sun City
Youngtown
Peoria
Glendale
Litchfield Park
Maryvale
Tolleson
Goodyear
Avondale
PHOENIX
Cactus
Paradise Valley
Scottsdale
Tempe
South Phoenix
Guadalupe
Gilbert
Chandler
SALT RIVER INDIAN RESERVATION
GILA RIVER INDIAN RESERVATION
PHOENIX SOUTH MOUNTAIN PARK
TO PRESCOTT
TO TUCSON
CENTRAL MARICOPA COUNTY

Figure 11. Proposed Air Quality Surveillance System (Map Courtesy of First National Bank of Arizona)

Reproduced from best available copy.

compared to each previous year. This air quality comparison can be made in terms of the number of days each year the national CO and 0_x standards are exceeded. If this number increases from one year to the next, these two sites should be installed. Such a comparison of currently available data suggests that CO and 0_x air quality is actually improving, and it is unlikely that these two stations will be required. However, if 1972 or 1973 data indicates air quality degradation, it becomes important to measure the dispersion of pollutants into the suburbs, and these two stations should be used to maintain this surveillance. The additional capital cost for equipment and installation would be approximately $9000.

With regard to monitoring in downtown Phoenix, the strategy recommends that the MCHD mobile lab be used to measure (as a minimum) CO one week per month from August through April and 0_x and HC one week per month from April through August. This data should be used to establish and update the correlation between air quality in the heart of Phoenix and data taken at MCHD (1), which is approximately 18 blocks east. It has been reported (Contact Report E-3) that such analyses have been made and that data from the two locations correlates closely; however, it is important to monitor any changes in this correlation which growth effects or population redistribution may produce.

It is suggested that the MCHD mobile lab also be used to sample CO near intersections or street sections which are prone to traffic congestion. A detailed schedule of time and location is not suggested; however, such sampling should be carried out in the fall and winter months (August through April) during the hours 4 p.m. to 1 p.m., since this is the typical period of maximum CO concentration.

The following are strategy recommendations involving the administration of the Phoenix air quality surveillance system:

1) It is of the utmost importance with regard to measuring progress of strategy implementation that ambient air quality data be reduced to the sample bases and format required in state reports to the EPA and that these reports be submitted punctually.
2) Because of the seriousness of the air quality problem in Phoenix, it is especially important that close cooperation be practiced between ASHD and MCHD. It is specifically recommended that MCHD provide ASHD with a monthly data report which summarizes measured pollutant concentrations for the month.
3) It is recommended that the utilization of computer systems for data reduction and transmission be evaluated by MCHD in light of the expanded surveillance network recommended by the strategy. Included among candidate systems are computer leasing, programmable calculators and timesharing. For example, such repetitive manipulations as sample base reductions are naturally within the realm of computer applications. Furthermore, automated or semi-automated tending of additional sampling stations is likely to be more cost-effective than using manpower only.

The ASIP has recommended that CO, O_x, and NO_2 monitors be installed in Tucson in 1973 and 1974. The strategy recommends that these monitors not be installed later than the dates indicated by the ASIP. Federal cooperation in funding this installation is encouraged. The following items should be primary objectives of the utilization of the Tucson Set II pollutant surveillance system:

1) Evaluate the natural background concentrations of CO, HC, O_x, and NO_2.
2) Evaluate nonmethane HC as a percent of total HC.
3) Identify and document seasonal and diurnal trends in the ambient concentration of each pollutant in Tucson, and correlate these trends with meteorological conditions.
4) Determine the geographical extent of high pollutant concentrations in and near Tucson.
5) Determine the relationship between HC concentration and O_x concentration (this will probably consist of verifying the Barth data).

These items will provide a strong foundation for determining strategies for control of Set II pollutants in Tucson.

Vehicle Emissions

The Periodic Vehicle Inspection (PVI) Program begun by the ASHD appears to be a good basic program for the surveillance of vehicle emissions in the State of Arizona. The technical, social, and economic aspects of this program have not yet been completely evaluated but are currently under study by ASHD. Precise details in planning future phases of this program will be developed as a result of this study by ASHD. The strategy endorses the Arizona PVI Program but strongly advises that its implementation be expedited. The current ASHD timetable (described in Table 11) proposes that Part II, mandatory inspection in Maricopa and Pima counties, be carried out from July 1973 to July 1975. Within this time period, the actual target date for Part II completion should be moved as close to the start date as possible; a preferable target date would be July 1974. This would allow several months leeway before the beginning of 1975 for solving start-up problems which are almost inevitable in program implementation.

Transportation

As an input to the continuing surveillance of air quality and mobil source emissions, MAGTPP, the area wide transportation planning coordinating agency, should regularly report travel data to the state health department.

In the initial stage of the program, this would consist of reporting on an annual basis estimates of average area-wide daily VMT stratified by vehicle type. This data should be supplemented by estimates of VMT variations by day of week and month of year and estimates of distribution of VMT by speed ranges. Appropriate arrangments would be necessary to insure input of required data by local jurisdictions and the Arizona State Highway Department to MAGTPP for processing.

After 1975, if Phase II VMT reduction measures were deemed necessary, more frequent reporting would be required to monitor effectiveness in achieving the specified VMT reductions. Development of an efficient method of estimating area-wide average daily VMT on the basis of selected sample counts to minimize the time effort and cost of more frequent reporting appears desirable. The following is a suggested surveillance program if the Phase II VMT restriction measures are imposed:

- Identify a selected number of traffic counting stations (probably no more than 30) which can be regularly monitored, preferably by the highway department and from which reliable estimates of area-wide average daily VMT can be made. Use of permanent count stations with induction loop counters appears desirable.
- Develop factors for estimating area-wide daily VMT on the basis of the count sampling.
- Conduct counts and estimate area-wide average daily VMT every three months and report this data to the state health department. The detailed supplementary data need be reported only on an annual basis.

APPENDIX A

GLOSSARY

PLAN	-	An implementation plan, under Section 110 of the Clean Air Act, to attain and maintain a neutral standard.
CONTROL MEASURE	-	A specific method or approach for reducing emission from one or more sources.
CONTROL STRATEGY	-	A combination of measures designated to achieve the aggregate reduction of emissions necessary to attain national standard.
REID VAPOR PRESSURE (RVP)	-	A measure of gasoline volatility based on a specific test procedure.
PRIMARY STANDARD	-	A national primary ambient air quality standard promulgated pursuant to Section 109 of the Clean Air Act. (Designed to protect public health.)
SECONDARY STANDARD	-	A national secondary ambient air quality standard promulgated pursuant to Section 109 of the Clean Air Act. (Designed to protect public welfare.)
NATIONAL STANDARD	-	Either a primary or secondary standard.
REGION	-	An air quality control region designated by the Secretary of HEW or the Administrator or any area designated by a state agency as an air quality control region and approved by the administrator or any area of a state not designated as included in quality control region under the above.

APPENDIX B

EMISSIONS DATA

This appendix summarizes calculations and data developed for emissions from specific source categories.

The first calculation provides an estimate for future fuel oil use at Salt River Project power plants. This estimate is based on the predicted power production of SRP plants and the projected fuel use schedule at Arizona Public Services plants; proportionality is assumed.

Table B-1 shows exhaust non-methane hydrocarbons emitted from local Arizona Public Services and Salt River Project power plants. Fuel use schedules* and the appropriate emission factor [35] for oil-burning power plants (HC emissions from natural gas burning are assumed negligible) were used in the following manner:

oil use per year X Emission factor = emissions per year

Emission rate units were converted to g/sec on a continuous operating basis.

Tables B-2 through B-4 were prepared in similar manner, using the appropriate emission factor in each case. Since the fuel throughput for the plants was a total value for each plant, throughput per tank was calculated on the assumption that relative throughput per tank is proportional to the relative capacity of the tank as compared to the total plant storage capacity.

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*Contact Reports E-5 and E-6

Power Plants

SRP - Projected Oil Use

	Projected Fuel Use	
Year	Gas	Oil (D2)
1973	?	3×10^6 Bbl
1977	0	?

	Projected Power Generation		
Year	Agua Fria (10^6 KWH)	Kyrene Stm. (10^6 KWH)	Kyrene Gas Turb. (10^6 KWH)
1973	3060	380	260

Assume distribution of fuel equivalent to power production:

Total 1973 KWH = 3700 KWH

Agua Fria: $\frac{3060}{3700}(3 \times 10^6 \text{ Bbl}) = 2.5 \times 10^6 \text{ Bbl}$

Kyrene Stm: $\frac{380}{3700}(3 \times 10^6) = 0.3 \times 10^6$

Kyrene Gas Turb.: $\frac{260}{3700}(3 \times 10^6) = 0.2 \times 10^6$

Assume SRP Fuel Use Schedule will be the same as APS Plants relative to use in 1973.

APS Steam

Year	Total Oil (10^6 Bbl)	$K_i = \left(\frac{\text{Bbl Oil}_i}{\text{Bbl Oil}_{1973}}\right)$
1969	0	0
1973	1.3	1.0
1975	3.6	2.8
1977	3.0	2.3
1978	2.6	2.0
1980	2.4	1.8

APS Gas Turb.

Year	Total Oil (10^6 Bbl)	$K_i = \left(\frac{\text{Bbl Oil}_i}{\text{Bbl Oil}_{1973}}\right)$
1969	0	
1973	.060	1.0
1975	0.98	16.
1977	0.60	10.
1978	0.50	8.3
1980	0.58	9.7

Apply these relative figures to SRP 1973 Oil Use:

Agua Fria (Stm.): 1973 Oil Use = 2.5×10^6 Bbl

Year	K_1	K_1 2.5×10^6 = Oil Use (10^6 Bbl)
1973	1.0	2.5
1975	2.8	7.0
1977	2.3	5.8
1978	2.0	5.0
1980	1.8	4.5

Kyrene Stm.: 0.3×10^6 Bbl

1973	1.0	0.3
1975	2.8	0.8
1977	2.3	0.7
1978	2.0	0.6
1980	1.8	0.5

Kyrene Gas Turb.: 0.2 x 10^6 Bbl

Year	K_i	K_i 0.2 (10^6 Bbl)
1973	1.0	0.2
1975	16.	3.2
1977	10.	2.0
1978	8.3	1.7
1980	9.7	1.9

Table B-1. CALCULATION SUMMARY: NON-METHANE EXHAUST HC EMISSIONS FROM LOCAL POWER PLANTS

Plant	Power Agency	Year	Steam Units: 10^6 Gal. Oil	HC[a] Ton/Yr	HC[b] g/sec.	Turbine Units: 10^6 Gal. Oil	HC[a] Ton/Yr	HC[b] g/sec.
Ocotillo	APS	1969	0	0	0	0	0	0
		1975	82.53	82.53	2.38	10.16	10.16	0.293
		1977	61.95	61.95	1.78	6.26	6.26	0.180
		1978	51.53	51.53	1.48	5.17	5.17	0.149
		1980	46.45	46.45	1.34	6.05	6.05	0.174
West Phoenix	APS	1969	0	0	0	0	0	0
		1975	5.25	5.25	0.151	10.21	10.21	0.294
		1977	3.95	3.95	0.114	6.30	6.30	0.181
		1978	3.28	3.28	0.094	5.21	5.21	0.150
		1980	2.94	2.94	0.085	6.05	6.05	0.174
Agua Fria	SRP	1969	0.67	0.67	0.019	---	---	---
		1975	290.	290.	8.35	---	---	---
		1977	240.	240.	6.91	---	---	---
		1978	210.	210.	6.05	---	---	---
		1980	190.	190.	5.47	---	---	---
Kyrene	SRP	1969	.036	.036	0.001	0	0	0
		1975	34.	34.	0.979	130.	130.	3.74
		1977	29.	29.	0.835	84.	84.	2.42
		1978	25.	25.	0.720	71.	71.	2.04
		1980	21.	21.	0.605	80.	80.	2.30

[a] EF = 2 lb/10^3 Gal. = 1 Ton/10^6 Gal.

[b] 1 Ton/Yr = .0288 g/sec. (Continuous Operation Through Year)

Table B-2. HC EMISSIONS FROM POWER PLANT FUEL STORAGE

Plant	Type Oil	Type Tank or Roof	1969 Storage (Bbl)	1969 Storage (10^6 Gal.)	Total 1975 Storage[c] (Bbl)	Total 1975 Storage (10^6 Gal.)
Ocotillo	Resid. Mix #5, #6	Fixed	1-55,000	1-2.3	1-55,000	1-2.3
		Floating			3-100,000	3-4.2
	Light Oil	Fixed	1-21,000	1-0.88	1-21,000	1-0.88
	Diesel #2	Fixed	1-30,000	1-1.3	1-30,000	1-1.3
West Phoenix	Resid. #6	Fixed	1-55,000	1-2.3	1-55,000	1-2.3
		Fixed	1-4,000	1-0.68	1-4,000	1-0.68
	Diesel #2	Fixed	1-30,000	1-1.3	1-30,000	1-1.3
Agua Fria	Diesel #2	Sealed[a]	1-131,000	1-5.5	1-131,000	1-5.5
		Sealed			1-200,000	1-8.4
		Vented[b]	1-110,000	1-4.6	1-110,000	1-4.6
Kyrene	Diesel #2	Sealed	1-23,000	1-0.97	1-23,000	1-0.97
		Sealed			2-131,000	2-5.5
		Vented	1-10,000	1-0.42	1-10,000	1-0.42

---

[a] Assumed Equivalent to Flotation Roof

[b] Assumed Equivalent to Fixed Roof

[c] 1977, 1978 and 1980 Storage was Assumed Same as 1975, Since Power Demand Does Not Increase

Table B-2 (Continued) BREATHING LOSSES

Plant	Breathing Loss Emission Factor	1969 HC Emissions Per Tank (10^3 LB/YR)	1969 HC Emissions Per Oil Type (10^3 LB/YR)	1975 HC Emissions[d] Per Tank (10^3 LB/YR)	1975 HC Emissions[d] Per Oil Type (10^3 LB/YR)
Ocotillo	0.4 LB/Day-1,000 Gal.	340.	340.	340.	760.
	140 LB/Day-Tank	---		420.	
	0.4 LB/Day-1,000 Gal.	130.	130.	130.	130.
	0.4 LB/Day-1,000 Gal.	200.	200.	200.	200.
West Phoenix	0.4 LB/Day-1,000 Gal.	340.	440.	340.	440.
	0.4 LB/Day-1,000 Gal.	100.		100.	
	0.4 LB/Day-1,000 Gal.	200.	200.	200.	200.
Agua Fria	140 LB/Day-Tank	51.	740.	51.	790.
	140 LB/Day-Tank	---		51.	
	0.4 LB/Day-1,000 Gal.	690.		690.	
Kyrene	140 LB/Day-Tank	51.	110.	51.	210.
	140 LB/Day-Tank	---		100.	
	0.4 LB/Day-1,000 Gal.	63.		63.	

---

[d] Losses for 1977, 1978, 1980 Assumed Equal to 1975 Losses

Table B-2. (Continued) BREATHING LOSSES

	1969 HC Emissions		1975 HC Emissions	
Plant	Per Oil Type (G/Sec)	Plant Total (G/Sec)	Per Oil Type (G/Sec)	Plant Total (G/Sec)
Ocotillo	4.9	9.7	11	15.8
	----		---	
	1.9		1.9	
	2.9		2.9	
West Phoenix	6.3	9.2	6.3	9.2
	2.9		2.9	
Aqua Fria	11	11	11	11
Kyrene	1.6	1.6	3.0	3.0

Table B-2 . (Continued) WORKING LOSSES

Plant	Working Loss Emission Factor (LB/10^3 Gal. Throughput)	1969 Throughput[e] (10^6 Gal./Yr)	1975 Throughput[f] (10^6 Gal./Yr)	1977 Throughput (10^6 Gal./Yr)	1978 Throughput (10^6 Gal./Yr)	1980 Throughput (10^6 Gal./Yr)
Ocotillo	11.	Negligible	13.	10.	9.	8.
	Negligible	Negligible	69.	52.	43.	38.
	11.	Negligible	10.	10.	10.	10.
	11.	Negligible	10.	6.	5.	6.
West Phoenix	11.	Negligible	4.9	3.7	3.1	2.8
	11.	Negligible	0.3	0.3	0.2	0.2
	11.	Negligible	10.	6.	5.	6.
Agua Fria	Negligible	Negligible	----	----	----	----
	Negligible	Negligible	----	----	----	----
	11.	Negligible	70.	60.	50.	50.
Kyrene	Negligible	Negligible	----	----	----	----
	Negligible	Negligible	----	----	----	----
	11.	Negligible	1.4	1.2	1.0	0.8

---

[e] In 1909 Oil was Stored for Standby Use Only

[f] When more than One Tank was Used at a Plant, Throughput was Assumed Proportional to Relative Tank Capacity

Table B-2. WORKING LOSSES (continued)

	1975 HC Emissions		1977 HC Emissions		1978 HC Emissions		1980 HC Emissions	
Plant	Per Tank Type (10^3 LB/YR)	Plant Total (10^3 LB/YR)	Per Tank Type (10^3 LB/YR)	Plant Total (10^3 LB/YR)	Per Tank Type (10^3 LB/YR)	Plant Total (10^3 LB/YR)	Per Tank Type (10^3 LB/YR)	Plant Total (10^3 LB/YR)
Ocotillo	140.	1100.	110.	860.	99.	730.	88.	680.
	760.		570.		470.		420.	
	110.		110.		110.		110.	
	110.		66.		55.		66.	
West Phoenix	54.	170.	41.	110.	34.	91.	31.	99.
	3.3		3.3		2.2		2.2	
	110.		66.		55.		66.	
Agua Fria	Negligible		Negligible		Negligible		Negligible	
	Negligible		Negligible		Negligible		Negligible	
	770.	770.	660.	660.	550.	550.	550.	550.
Kyrene	Negligible		Negligible		Negligible		Negligible	
	Negligible		Negligible		Negligible		Negligible	
	15.	15.	13.	13.	11.	11.	9.	9.

Table B-2. (Continued) WORKING LOSSES and TOTAL EMISSIONS

Plant	Working Losses 1969 (G/Sec)	1975 (G/Sec)	1977 (G/Sec)	1978 (G/Sec)	1980 (G/Sec)	Total Evaporative HC Emissions: Working Loss & Breathing Loss 1969 (G/Sec)	1975 (G/Sec)	1977 (G/Sec)	1978 (G/Sec)	1980 (G/Sec)
Ocotillo	0	16.	12.	10.	10.	9.7	32.	28.	26.	26.
West Phoenix	0	2.4	1.6	1.3	1.4	9.2	12.	11.	10.	11.
Agua Fria	0	11.	9.5	7.9	7.9	11.	22.	20.	19.	19.
Kyrene	0	0.2	0.2	0.2	0.1	1.6	3.2	3.2	3.2	3.1

Table B-3. CALCULATION SUMMARY: NO_x EMISSIONS FROM LOCAL POWER PLANTS (STEAM UNITS)

Plant	Power Agency	Type Oil	Year	10^6 Bbl Oil	10^6 Gal.[a] Oil	NO_x 10^3TON/YR (Oil)[b]	10^6 FT Gas	NO_x 10^3TON/YR (Gas)[c]	NO_x 10^3TON/YR Total	Data Ref.
Ocotillo	APS	Resid. Mix #5, #6	1969	0	0	0	9,330.423	1.819	1.819	
			1975	1.965	82.53	4.333	582.0	0.1135	4.446	
			1977	1.475	61.95	3.252	0	0	3.252	
			1978	1.227	51.53	2.706	0	0	2.706	
			1980	1.106	46.45	2.438	0	0	2.438	
West Phoenix	APS	Resid. Mix #5, #6	1969	0	0	0	0	0	0	
			1975	0.125	5.25	0.275	36.96	.00721	0.282	
			1977	0.094	3.95	0.207	0	0	0.207	
			1978	0.078	3.28	0.172	0	0	0.172	
			1980	0.070	2.94	0.154	0	0	0.154	

---

[a] 1 Bbl = 42 Gal. (Oil)

[b] EF = 105 LB $NO_x/10^3$ Gal. = .0525 TON/10^3 Gal.

[c] EF = 390 LB $NO_x/10^6FT^3$ = .195 TON/10^6 FT^3

Table B-3. (Continued)

Plant	Power Agency	Type Oil	Year	10^6 Bbl Oil	10^6 Gal. Oil	NO_x 10^3TON/YR (Oil)	10^6 FT^3 Gas	NO_x 10^3TON/YR (Gas)	NO_x 10^3TON/YR Total	Data Ref.
Agua Fria	SRP	D2 Diesel	1969	0.016	0.067	.035	18,800.	3.67	3.70	
			1975	7.0	290.	15.	770.	0.150	15.	
			1977	5.8	240.	13.	0	0	13.	
			1978	5.0	210.	11.	0	0	11.	
			1980	4.5	190.	10.	0	0	10.	
Kyrene	SRP	D2 Diesel	1969	0.00085	.036	.0019	2,160.	0.421	0.423	
			1975	0.8	34.	1.8	99.	0.19	2.0	
			1977	0.7	29.	1.5	0	0	1.5	
			1978	0.6	25.	1.3	0	0	1.3	
			1980	0.5	21.	1.1	0	0	1.1	

Table B-4. CALCULATION SUMMARY: NO_x EMISSIONS FROM LOCAL POWER PLANTS (TURBINE UNITS)

Plant	Power Agency	Type Oil	Year	10^6 Bbl Oil	10^6 Gal. Oil	NO_x 10^3 TON/YR (Oil)	10^6 FT3 Gas	NO_x 10^3 TON/YR (Gas)	Turbine NO_x 10^3 TON/YR Total	Data Ref.
Ocotillo	APS	Resid. Mix #5, #6	1969	0	0	0	0	0	0	
			1975	0.242	10.16	0.533	110.7	.0216	0.5546	
			1977	0.149	6.26	0.329	0	0	0.329	
			1978	0.123	5.17	0.271	0	0	0.271	
			1980	0.144	6.05	0.318	0	0	0.318	
West Phoenix	APS	Resid. Mix #5, #6	1969	0	0	0	0	0	0	
			1975	0.243	10.21	0.536	111.2	.0217	0.558	
			1977	0.150	6.30	0.331	0	0	0.331	
			1978	0.124	5.21	0.274	0	0	0.274	
			1980	0.144	6.05	0.318	0	0	0.318	

Table B-4. (Continued)

Plant	Power Agency	Type Oil	Year	10^6 Bbl Oil	10^6 Gal. Oil	NO_x 10^3TON/YR (Oil)[a]	10^6 FT^3 Gas	NO_x 10^3TON/YR (Gas)[b]	NOx 10^3TON/YR Turbine Total	Data Ref.
Kyrene	SRP	D2 Diesel	1969	0	0	0	0	0	0	
			1975	3.2	130.	6.8	66	.013	6.8	
			1977	2.0	84.	4.4	0	0	4.4	
			1978	1.7	71.	3.7	0	0	3.7	
			1980	1.9	80.	4.2	0	0	4.2	

---

[a] EF = .0525 TON/10^3 Gal.

[b] EF = .195 TON/10^6 FT^3

Power Plant Operating Schedules

Daily Schedule*:

Summer:

10 A.M. to 10 P.M.: 75% to 100% full load

10 P.M. to 10 A.M.: 10% to 30% full load

Winter:

8 A.M.: Small peak; assume 50% full load

Seasonal Schedule[+]:

November thru April: 0% to 40% of fuel

May thru October: 60% to 100% of fuel

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* Contact Report E-3

[+] Contact Reports E-3 and E-6

Tank Farm

Breathing Losses

1969

- o No. fixed-roof tanks: 0
- o No. floating-roof tanks: 68
  (Assume cone-covered floating roof tanks emit at same rate as floating roof tanks)

1975

- o No. fixed-roof tanks: 0
- o No. floating-roof tanks: 71

Emission Factor = 140 LB/Day·Tank for floating roof tanks [35]

1969 HC Emissions =

$$(68\ \text{tanks})(140\ \frac{\text{LB}}{\text{Day}\cdot\text{Tank}}\ \frac{1\ \text{Day}}{24\ \text{Hr}}\ \frac{1\ \text{Hr}}{3600\ \text{sec}}\ 453.6\ \frac{\text{G}}{\text{LB}}$$

$= 50.\ \frac{\text{G}}{\text{sec}}$ on continuous basis

1975 HC Emission $= 50\ \frac{71}{68} = 52\ \frac{\text{G}}{\text{sec}}$

Assuming emissions increase at $\frac{1}{3}\ \frac{\text{G}}{\text{sec}}$ Year:

1977: 53 g/sec

1978: 53 g/sec

1980: 54 g/sec

Working Losses

1972 Gasoline Throughput* $= 1.4 \times 10^6$ Bbl/Mo

$$= (1.4 \times 10^6)(42 \frac{\text{Gal}}{\text{Bbl}}) = 58.8 \times 10^6 \frac{\text{Gal}}{\text{Mo.}}$$

$$= 705.6 \times 10^6 \text{ Gal/Yr.}$$

Assume gasoline throughput varies as vehicle registration in Maricopa County:[+]

$$\text{Registration Rate} = \frac{840{,}000 - 500{,}000}{10 \text{ yrs}} = 34{,}000/\text{Yr}^2$$

1972 Registration 570,000

$$\text{Per cent yearly change} = \frac{34}{570} = 6\%$$

Thus

$$\text{Gasoline Throughput (year n)} = 705.6\ (1.06^{(n-1972)}) \times 10^6$$

Year	Gasoline Throughput (10^6 Gal/Yr)
1969	592.4
1975	840.4
1977	944.2
1978	1000.9
1980	1124.6

---

* Contact Report E-4

[+] Data from [1.]

Assume tank truck filling is 75% submerged fill. Emission factor [35]

$= 12 - .75(5) = 8.4\ \text{lb}/10^3\ \text{Gal}$

Thus:

	Emissions	
Year	10^6 Lb/Yr	G/Sec
1969	5.0	72
1975	7.0	100
1977	7.9	110
1978	8.4	120
1980	9.4	140

Filling Station Losses

1969 Emissions

Gasoline Throughput, Maricopa County, 1969 = 434×10^6 gal. [1.]

HC Emission Factors [35.]

Filling Service Station Tanks (MCHD recommends 90% splash fill, 10% submerged [18.]) — 11.5 lb/1000 gal.

Filling Auto Tanks : 12 lb/1000 gal.

Calculated
1969 Emissions = $(434 \times 10^6 \text{ gal.})(23.5 \text{ lb}/10^3 \text{ gal}) = 10.2 \times 10^6$ lb
(5.1×10^3 tons)

Converting units to g/sec on a continuous basis
(24 hr/day, 365 days/yr):

$$(10.2 \times 10^6 \text{ lb/yr}) \left(.0144 \frac{\text{G Yr}}{\text{sec } 10^3 \text{ lb}}\right) = \underline{147 \text{ G/sec}}$$

The MCHD Emission Inventory for 1970 [18.] estimates service station losses at 16.88 ton/day (177 G/sec). This is 20% higher than my estimate. However, the MCHD inventory seems to contain a multiplicative error. Using their numbers, (1182×10^3 gal/day) (11 + 11.6) lb/10^3gal = 13.36 tons/day, (Not 16.88). This converts to 140 G/sec.

Projected Emissions: (No Control)

Estimate yearly increase, from Arizona Statistical Review 1972:

Year	(Maricopa Cty) Gasoline Consumption	Consumption Increase Ratio
1966	331	1.03
1967	340	1.11
1968	379	1.14
1969	434	1.10
1970	480	1.05
1971	506	

Use Ratio of 1.1 to project consumptions

Consumption in Years from 1971 = (506) $(1.10)^n$

Year	n (Years)	$(1.1)^n$	Projected Consumption (10^6 gal)	Projected HC Emission* (G/sec)
1975	4	1.46	739.	250.
1977	6	1.77	896.	303.
1978	7	1.95	987.	334.
1980	9	2.36	1194.	404.

---

*Using same emission factor as 1969: 23.5 lb/10^3 gal.

Effective Stack Heights

From Turner Workbook, [3, P.31]

$$\Delta H = \frac{V_s d}{u} \left(1.5 + 2.68 \times 10^{-3}\, p\, \frac{Ts - Ta}{Ts}\, d\right)$$

ΔH = Rise of plume above stack

V_s = Stack gas veloc, $\frac{m}{sec}$

d = Stack I.D., m

u = Wind speed, m/sec

p = Atmospheric Pressure, mb

T_s = Stack gas temp, o_k

T_a = Air temp, o_k

NOTE: Exact calculations for effective stack height ($H_{eff} = H_{stack} + \Delta H$) are probably not required for the source - receptor distances involved.

Assume, for all sources with actual stacks:*

V_s = 10 m/sec

d = (8 ft)(.3 m/ft) = 2.4

u = (3 mi/hr) $\frac{1\ hr}{3600\ sec}$ 1609 $\frac{m}{mi}$ = 1.34 m/sec

p = 1013 mb

$T_s = 120^oC = 393^oK$

$T_a = 70^oF = 21^oC = 294^oK$

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*Contact Report E-6

Thus:

$$\Delta H = \frac{10(2.4)}{1.34}\left(1.5 + 2.68 \times 10^{-3}(1013)\frac{(393 - 294)}{423}(2.4)\right)$$

$$= \frac{10(2.4)}{1.34}(1.5 + 1.5) = 50 \text{ m}$$

Effective Stack HT = $H_{eff} = H_{stack} + 50$ m

Salt River Indian Reservation Landfill
(Open Burning)

Population:

Towns Hauling to SRIR Landfill	1970 Census	1975 Projection
Scottsdale	133,000*	85,000*
Mesa		83,000*
SR Reservation	1,600‡	2,500*
Tempe	64,000*	84,000+
Paradise Valley	7,000*	9,000+
Total	206,000	264,000

Refuse: Use 4 lb/capita • day*

1970: (206,000) (4) = 824,000 lb/day

1975: (264,000) (4) = 1056,000 lb/day

Assume:

1. 1969 refuse haul was same as 1970
2. In 1969, 10% of hauled refuse was burnt*
3. In 1975, 0% of hauled refuse will be burnt*

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*Contact Report E-7

+My estimate

‡[1,P.38]

Tonnage Burnt

1969: $(824 \times 10^3 \text{ lb/day})\ (.10)\ \left(\frac{1 \text{ ton}}{2000 \text{ lb}}\right) = 41.2$ ton/day

1975: $(1056 \times 10^3)\ (0) = 0$

Emissions:

	Emission Factor [35.] lb/ton	Emission Rate (G/sec)
CO	85	18.4
HC	30	6.4
NO_x	6	1.3

CO: 41.2 ton/day (85) lb/ton (454 g/lb) (1 day/24 hr) (1 hr/3600 sec)
= 41.2 (85) (.0052) = 18.4 g/sec

HC: 30 (41.2) (.0052) = 6.4

NO_x: 6 (41.2) (.0052) = 1.3

APPENDIX C

AIR QUALITY DATA

Figures C-1 through C-4 present diurnal peak maximum air concentration data for HC, CO, NO_2, and O_x, respectively. These data were taken from 1969 baseline worst day measurements. The time phase between the various pollutant measurements indicates the complexity in developing straightforward approaches and their control. For example, CO concentration are maximum at 12 midnight whereas NO_2 and O_x are maximum near noon. Figure C-5 further amplifies the importance of these time lags by comparing the concentrations of all four pollutants.

The assignment of stability classes represents a necessary step in utilizing the Semi-Diffusion Method for forecasting air quality. Table C-1 depicts the assignment of stability classes used in this analysis. The appropriate class is shown for each pollutant, depending on the amount of sunlight, cloud cover, and wind speed during the seasonal and daily periods which are typical for maximum concentrations of the pollutant. These classes were input to the air quality model described in Appendix G to estimate future air quality.

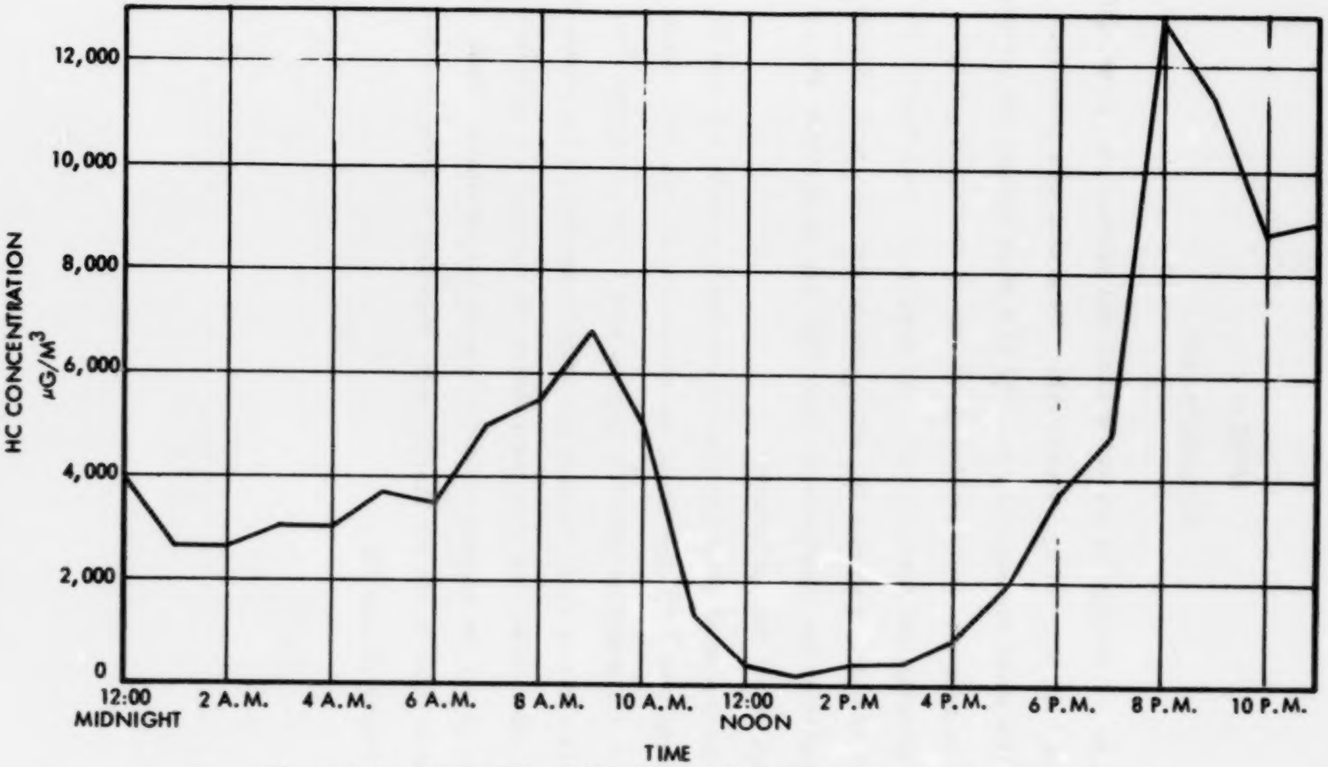

Figure C-1. Diurnal Variation of Hourly Average HC Concentration in Phoenix on 10 January 1969* (MCHD Data)

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*The Peak Hourly Average for 1969 Occurred on this date.

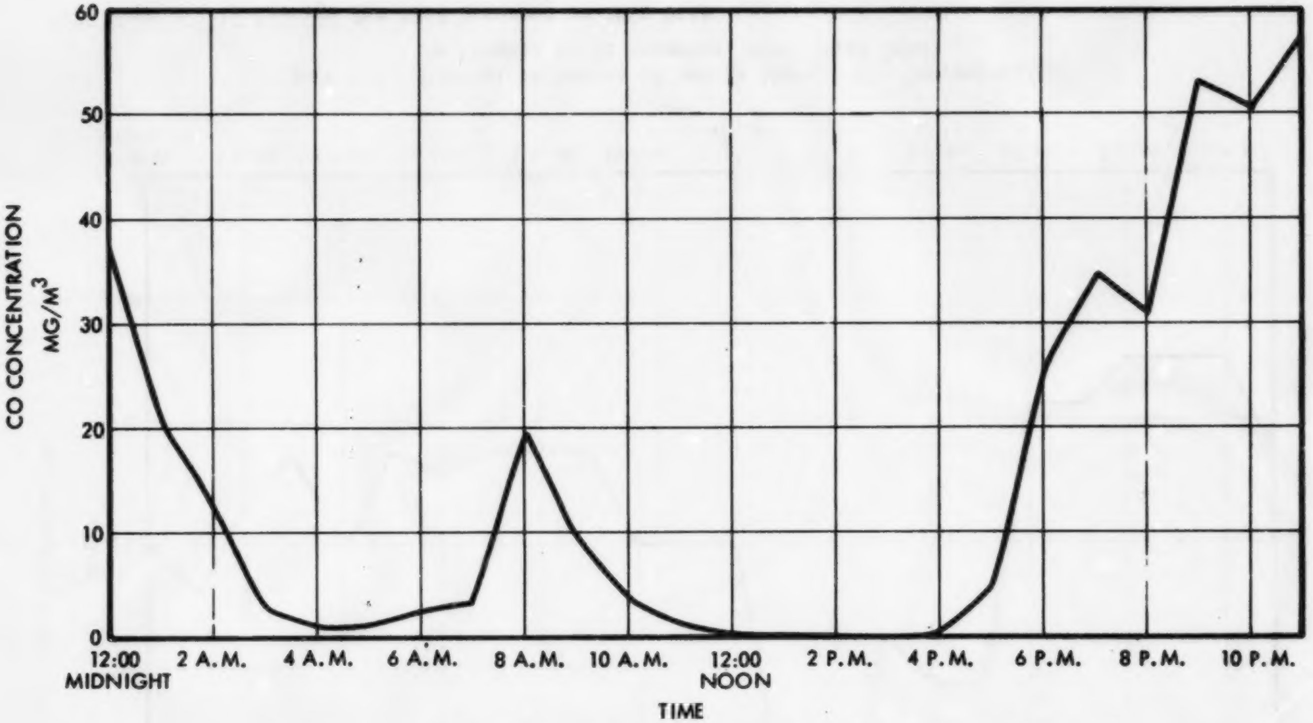

Figure C-2. Diurnal Variation of Hourly Average CO Concentration in Phoenix on 13 December 1969* (MCHD Data)

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*The Peak Hourly Average for 1969 Occurred on this Date.

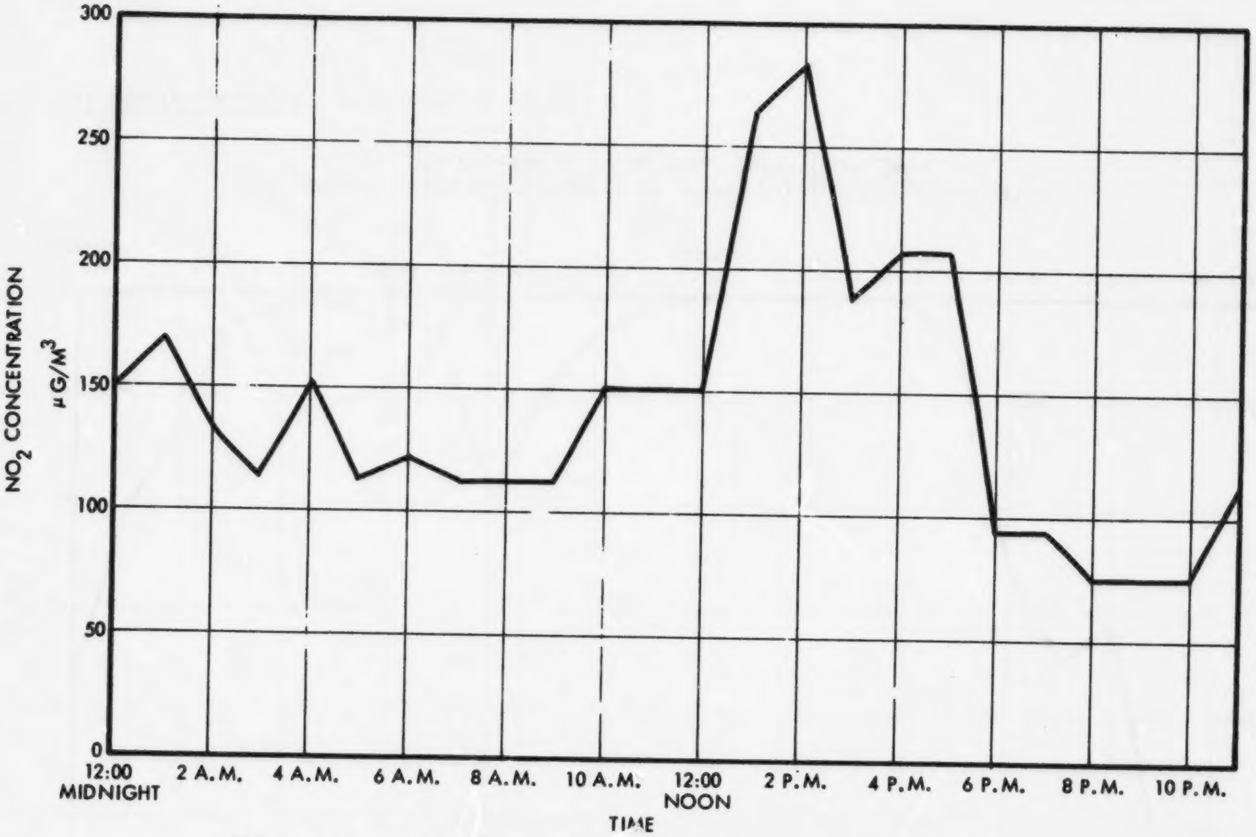

Figure C-3. Diurnal Variation of Hourly Average NO_2 Concentration in Phoenix on 15 November 1969* (MCHD Data)

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*The Peak Hourly Average for 1969 Occurred on this Date.

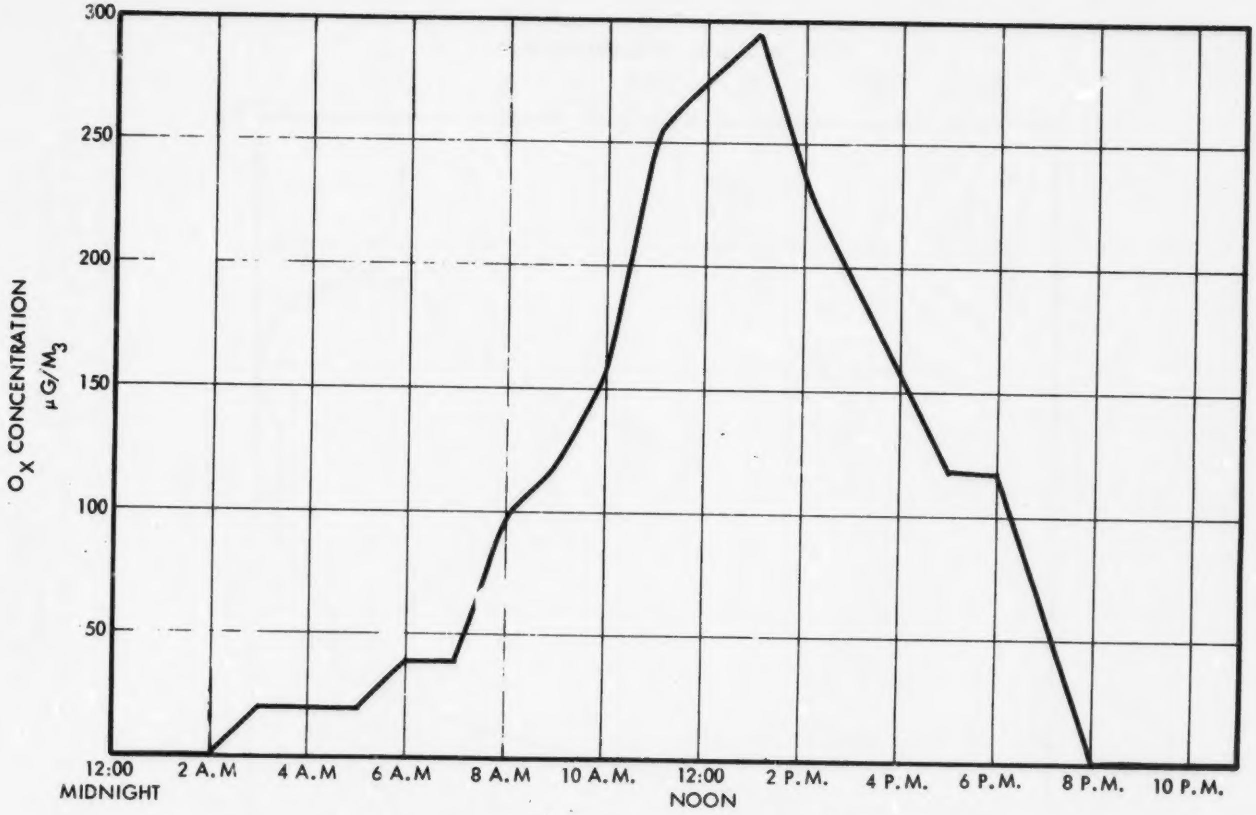

Figure C-4. Diurnal Variation of Hourly Average O_X Concentration in Phoenix on 26 May 1969* (MCHD Data)

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*The Peak Hourly Average for 1969 Occurred on this date.

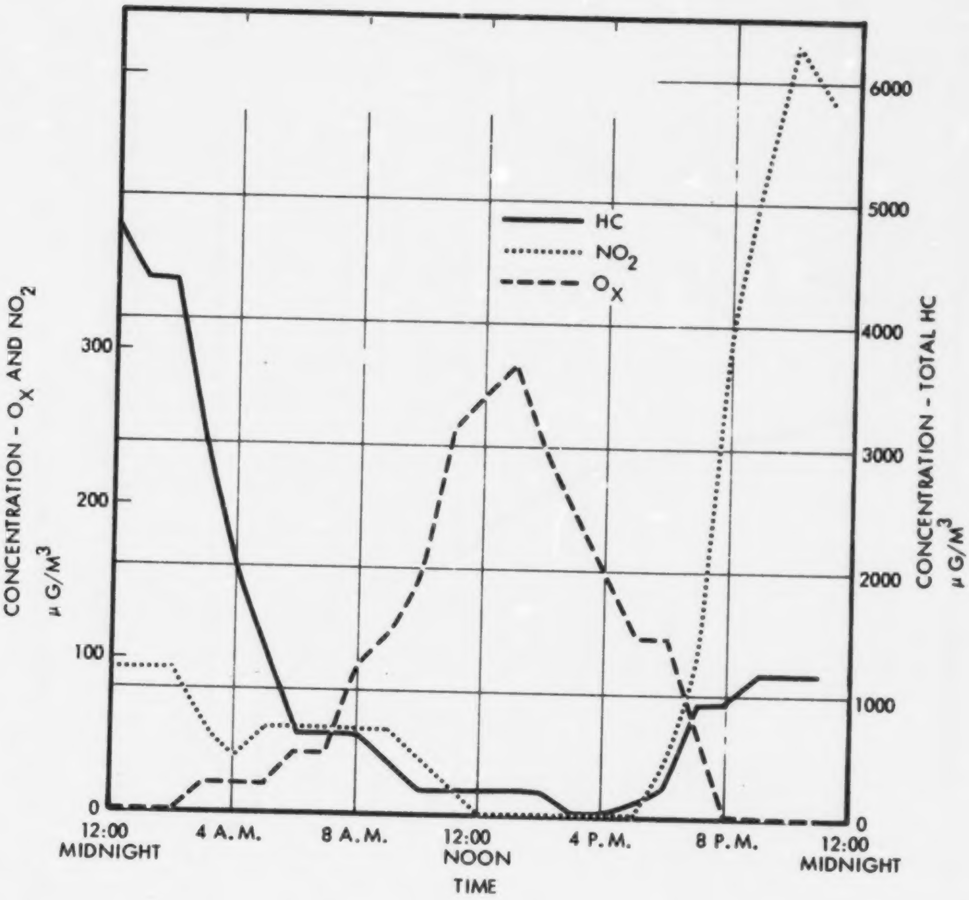

Figure C-5. Comparison: Diurnal Variation of Hourly Average Concentrations of HC, NO_2, and O_x in Phoenix on 26 May 1969*

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*The Peak Hourly Average of O_x Concentration for 1969 Occurred on this Date.

Table C-1. ASSIGNMENT OF STABILITY CLASSES

Pollutant	Peak Season	Approximate Peak Daily Period[a]	Approximate Wind Speed During This Period[b]		Assigned Stability Class[c]
			(MPH)	(M/Sec)	
CO	Fall-Winter	6pm - 2am	0	0	F
HC	Fall-Winter	5pm - 10am	0-3	0-1	F
O_x	Spring-Summer	8am - 6pm	1-6	0.5-3	A
NO_2	Fall-Winter	1pm - 5pm	0-4	0-2	B

[a] Figures C-1 through C-4

[b] Worst case, from MCHD data for peak days in 1969 (1 MPH = .447 M/sec)

[c] [2,P.6]

APPENDIX D

THE TRANSPORTATION SYSTEM

For purposes of transportation system analysis, the Phoenix planning area has been assumed to coincide with that of the Maricopa Association of Governments Transportation Planning Program (MAGTPP), a cooperative venture established under executive order in Maricopa County and the agency responsible for continuing comprehensive transportation planning in the region. The MAGTPP Area encompasses 1,200 square miles and includes the City of Phoenix.

Travel in the Phoenix region is almost entirely by private personal transportation. Less than one per cent of all personal trips in the area are made by public transportation. Urban activity in the region is characterized by a highly dispersed, low-density pattern.

The 1970 decennial census indicates a Maricopa County population of some 970,000 with over 90 per cent residing in the MAGTPP planning area, giving an average population density of 800 persons per square mile. However, overall population density is deceptive as distribution of population is non-homogeneous. Large parcels of land in agricultural use with virtually no population are interspersed among the urbanized land areas. The City of Phoenix, the area's largest municipality has a gross density of 2,300 persons per square mile with a few small areas of the most intensely developed land having densities at the 8,000 to 9,000 persons per square mile level.[1] Yet the area generally has lower population density than most cities of comparable size. In addition to dispersed residential development, the Phoenix Urban Area exhibits dispersed patterns of employment and retail activities. For example, five suburban shopping centers are patronized by more area households than is downtown Phoenix.[27]

Concomitant with low residential densities (as compared to other urban areas with similar populations) and the dispersed pattern of employment and retail activity, is a trip-making pattern which is also highly dispersed and lacking a strong focal point. Although downtown Phoenix has the area's greatest activity concentration, less than 10 per cent of the region's travel has origin or destination in the central area.

A dispersed pattern of development and trip making without a strong focal point is not well suited for public transportation because few major corridors of heavy travel exist. Transit service is most effective when large numbers of persons can be transported along a relatively limited number of linear routes, with origins and destinations in walking distance of the route. Absence of heavily defined travel corridors limits the role of transit in Phoenix.

In general, the street and highway system provides an adequate level of service throughout the region although some localized congestion problems are identifiable. Extensive freeway system planning has been done, but in terms of facilities constructed, the system has not reached a high level of development. Only some 10 per cent of the vehicle miles traveled in the Phoenix area are traveled on freeways. Parking is generally in adequate supply.

The following charts and tables provide some details of travel in the Phoenix area.

TABLE D-1 PRESENT AND PROJECTED INTERNAL TRAVEL [31]

	1970		1995	
Trip Type	# Trips	Duration (Minutes)	# Trips	Duration (Minutes)
Work	513,000	19.8	930,000	21.1
Shop	316,000	9.6	604,000	9.3
Social/Recreation	232,000	16.0	420,000	16.9
Misc. Home Based	416,000	15.2	718,000	15.9
Non-Home Based	451,000	14.2	817,000	15.1
Light Trucks	229,000	14.7	405,000	15.3
Heavy Trucks	139,000	13.8	238,000	14.3
	2,297,000		4,133,000	

TABLE D-2 CURRENT & FUTURE EXTERNAL AND THRU TRAFFIC[31]

	1970		1995	
Type	#Trips	Length (Miles)	#Trips	Length (Miles)
Thru	4,000	42	10,000	42
Local (External)	54,000	25	129,000	25

As can be seen by comparison of Tables D-1 and D-2, thru external travel only slightly over 2 per cent of the regional travel.

TABLE D-3 DAILY VEHICLE MILE TOTALS[31].

Year	Vehicle Mile Total
1970	11,500,000
1975	14,700,000
1995	28,200,000

Daily vehicle mile totals were estimated for 1972 and 1977, the base and forecast years by linear projection of the 1970-1975 growth rate as implied on Table D-3. Vehicle type breakdown was estimated from the trip data presented in Table 1 and average travel speed data.[31] Table D-4 indicates 1972 and 1977 daily miles traveled by vehicle type.

TABLE D-4 DAILY VEHICLE MILES TRAVELED

Vehicle Type	Per Cent Total	1972	1977
Auto	82.7	10,545,000	13,232,000
Light Truck	12.0	1,530,000	1,920,000
Heavy Truck	5.3	675,000	848,000
All	100.000	12,750,000	16,000,000

Breakdowns were similarly developed for travel within the City of Phoenix.

TABLE D-5 DAILY VEHICLE MILES TRAVELED WITHIN PHOENIX CITY LIMITS

Type	Per Cent Total	1972	1977
Auto	82.7	5,892,000	7,217,000
Light Truck	12.0	855,000	1,045,000
Heavy Truck	5.3	377,000	462,000
All	100.0	7,124,000	8,724,000

Table D-6 presents 1970 and 1971 motor vehicle registration for Maricopa County. Note that personal use panel and pick-up trucks (non-commercial trucks in the table) constitute more than 10 per cent of the private passenger vehicle fleet.

TABLE D-6 MOTOR VEHICLE REGISTRATION, MARICOPA COUNTY[1]

	1971	1970	Per Cent Increase
Passenger Cars	518,951	482,930	+7.5
Trucks - Commercial	75,392	68,985	+9.3
Trucks - Non-Commercial	64,813	58,370	+11.0
Buses	334	321	+ 4.0
Taxis	190	169	+12.4
Motorcycles & Scooters	24,141	19,768	+22.1

Figure D-1 presents population and auto registration projections for Maricopa County. By 1977 auto registration is anticipated to exceed 700,000 vehicles. Since a major portion of the region's growth, both in terms of population and vehicle registration, results from migration rather than internal growth, limitation of importation of older vehicles appears to have high potential for effectuation of mobil source emission reductions.

Tables D-7 through D-14 present 1972 and projected 1977 daily vehicle miles of travel by vehicle type and age. For light vehicles, population age distribution is based on current registration statistics with the distribution for the projection year smoothed to eliminate unusual variances in past model years. Figure D-2 presents the current age distribution of automobiles registered in Maricopa County and Phoenix city limits and contrasts these with that of Los Angeles County. The figure indicates the tendency of vehicles over 10 years age to remain a substantial portion of the in-use fleet in temperate climes where no winter salting of roads for antifreeze purposes occurs. Age distribution for heavy vehicles is based on national statistics as are the relative annual mileage driven figures for both heavy and light vehicles.

Although public transit services are provided by several operating agencies, one, the Phoenix Transit Corporation (PTC), serves more than 90 per cent of all transit patrons in the Phoenix area. PTC operates some 484 route miles over 30 routes on varying headways the minimum of which is 30 minutes, serving roughly 12,000 passengers on the average weekday. The system primarily serves transit dependent persons; some 90 per cent of the patronage is by persons who have no alternative to transit for their specific trip.

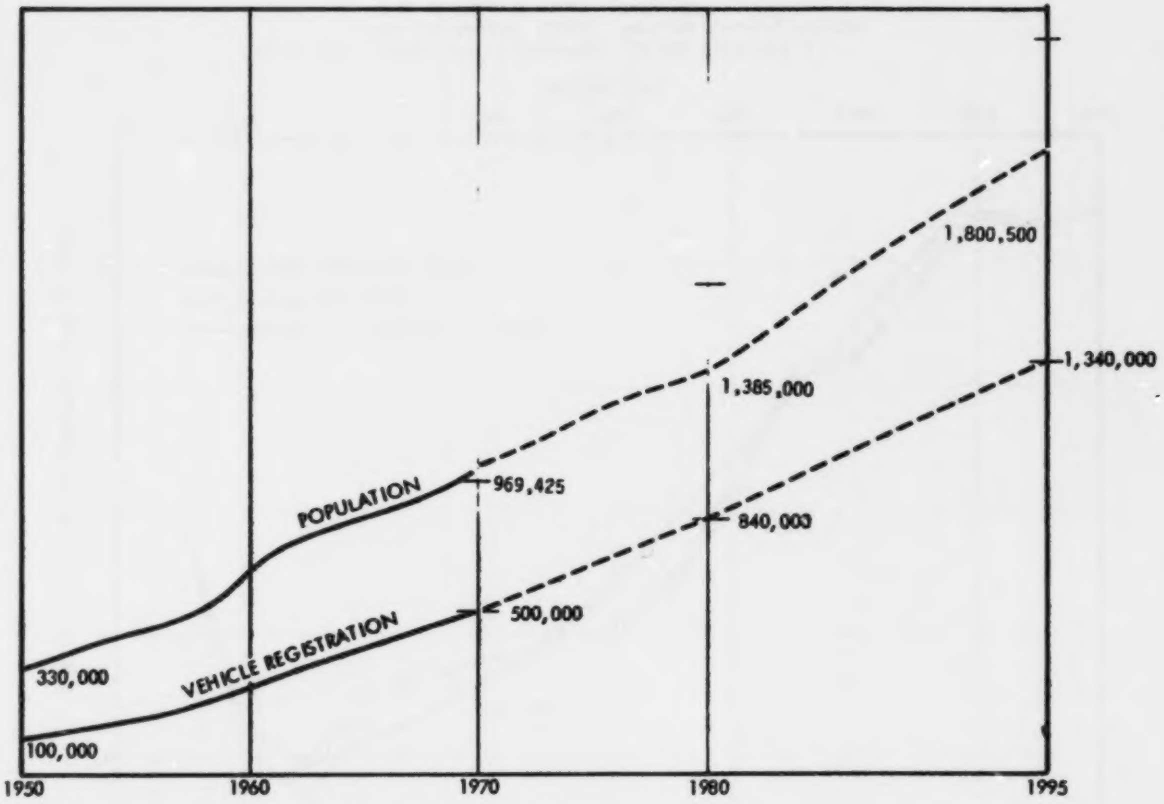


Figure D-1. Population and Vehicle Registration -- Maricopa County

Source: De Leuw, Cather/TRW Inc.
Estimated from various local projections.

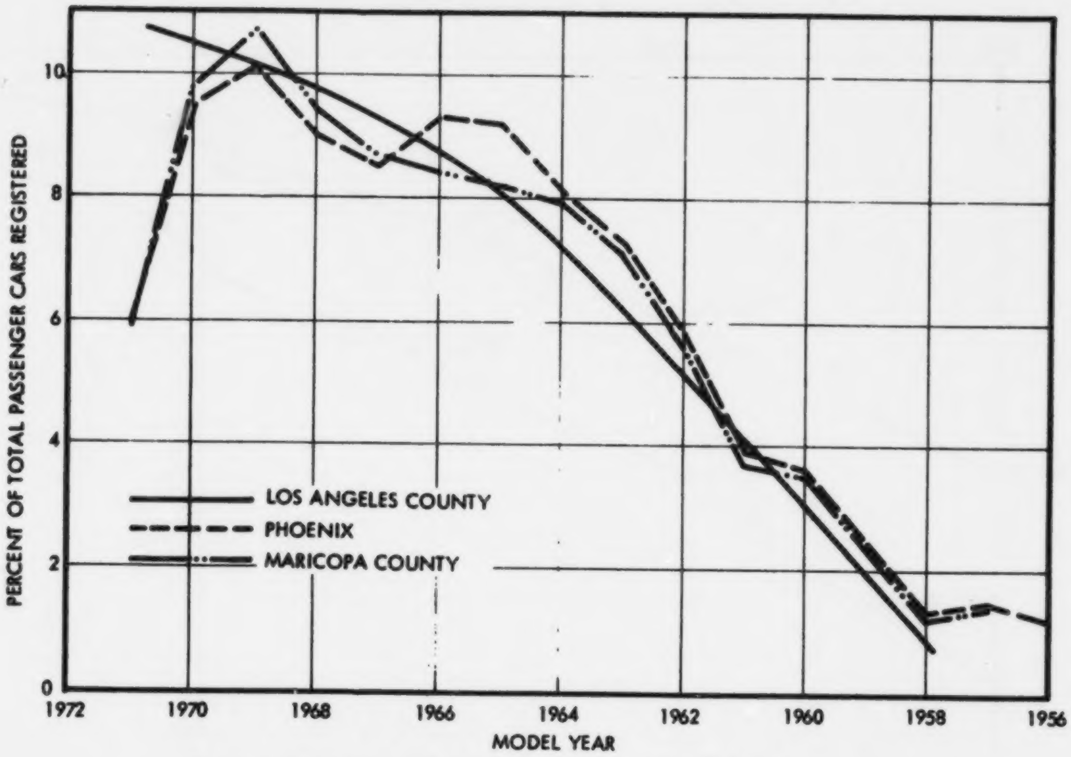


Figure D-2. Comparison of Passenger Car Age Distribution -- For Los Angeles County, Maricopa County, and the City of Phoenix as of 1 July 1971

TABLE D-7 PHOENIX REGIONAL AREA
1972 VEHICLE MILES OF TRAVEL PER DAY BY LIGHT VEHICLES

Age (years)	(1) Per Cent Lt. Vehicles In Use	(2) Relative Annual Mileage Driven	(3) Weighted Per Cent of Daily Travel	(4) Daily VMT Autos (Thousands)	(5) VMT Light Trucks (Thousands)
0	.059	3.8	2.899	306	44
1	.098	7.5	9.484	1,000	145
2	.107	11.4	15.752	1,660	241
3	.094	10.4	12.621	1,330	193
4	.088	9.5	10.790	1,140	165
5	.094	8.5	10.311	1,090	158
6	.092	7.8	9.279	980	142
7	.079	7.1	7.252	765	111
8	.071	6.4	5.875	620	90
9	.056	5.9	4.272	450	65
10	.037	5.5	2.631	277	40
11	.035	5.4	2.560	270	39
12	.023	5.4	1.606	169	25
Over 12	.067	5.4	4.678	493	72
	1.000	100.0	100.00	10,550	1,530

(1) POLK DATA, 1971

$(3) = \frac{(1) \times (2)}{\Sigma(1) \times (2)}$ expressed as per cent

Light Vehicles	Daily VMT	Per Cent Total VMT
Autos (incl. taxis)	10,545,000	82.7
Light trucks	1,530,000	12.0
Total light	12,075,000	94.7

TABLE D-8 PHOENIX REGIONAL AREA
1977 VMT (DAILY BY LIGHT VEHICLES)

Age (years)	(1) Fraction of Lt. Vehicles in Use	(2) Relative Annual Mileage Driven	(3) Weighted Fraction of Daily VMT	1977 VMT (Autos (Thousands)	1977 VMT (Lt. Trucks) (Thousands)
0	.059	3.8	.029	379	55
1	.099	7.5	.095	1,256	181
2	.107	11.4	.156	2,061	299
3	.104	10.4	1.38	1,831	265
4	.099	9.5	.120	1,586	230
5	.094	8.5	.103	1,357	197
6	.089	7.8	.089	1,180	171
7	.074	7.1	.068	895	130
8	.064	6.4	.052	692	100
9	.054	5.9	.041	542	79
10	.043	5.5	.031	407	59
11	.033	5.4	.220	298	43
12	.023	5.4	.016	218	33
Over 12	.058	5.4	.040	530	78
	1.000		1.000	13,232	1,920

(3) $\frac{(1) \times (2)}{\Sigma(1) \times (2)}$

1977 VMT Light Vehicles (Daily)	
Auto	13,232,000
Light Truck	1,920,000

TABLE D-9 PHOENIX REGIONAL AREA
1972 AND 1977 VEHICLE MILES TRAVELED PER DAY BY HEAVY TRUCKS

Age (years)	(1) Per Cent Heavy Trucks in Use	(2) Relative Annual Mileage Driven	(3) Weighted	1972 Daily VMT	1977 Daily VMT
0	.034	3.6	.016	11,000	14,000
1	.071	7.6	.074	50,000	63,000
2	.100	11.6	.156	105,000	132,000
3	.095	10.9	.140	94,000	119,000
4	.088	10.2	.121	82,000	103,000
5	.080	9.4	.102	69,000	86,000
6	.070	8.5	.081	55,000	69,000
7	.062	7.7	.064	43,000	54,000
8	.053	6.9	.049	33,000	42,000
9	.038	6.2	.032	22,000	27,000
10	.037	5.3	.026	18,000	22,000
11	.033	4.6	.021	14,000	18,000
12	.032	3.8	.016	11,000	14,000
Over 12	.207	3.7	.102	69,000	87,000
	1.000		1.000	675,000	848,000

(3) $\dfrac{(1) \times (2)}{\Sigma(1) \times (2)}$

	Heavy VMT	% Total VMT
1972	675,000	5.3
1977	848,000	5.3

Per 1967 Federal Census of Transportation:
Of all trucks registered in Arizona (excluding pickup and panel) 85.0 per cent gas, 12.3 per cent diesel or LPG, 2.7 per cent not reported. Assume 87.5 per cent heavy trucks gas, 12.5 per cent diesel or LPG.

TABLE D-10 PHOENIX URBAN AREA
SUMMARY OF VMT - ALL VEHICLES 1972 AND 1977

Age (years)	1972 Daily VMT (Thousands)			1977 Daily VMT		
	Auto	Light Truck	Heavy Truck	Auto	Light Truck	Heavy Truck
0	306	44	11	379	55	14
1	1,000	145	50	1,256	181	63
2	1,660	241	105	2,061	299	132
3	1,330	193	94	1,831	265	119
4	1,140	165	82	1,586	230	103
5	1,090	158	69	1,357	197	86
6	980	142	55	1,180	171	69
7	765	111	43	895	130	54
8	620	90	33	692	100	42
9	450	65	22	542	79	27
10	277	40	18	407	59	22
11	270	39	14	298	43	18
12	169	25	11	218	33	14
Over 12	493	72	69	530	78	87
	10,550	1,530	675	13,232	1,920	848

TABLE D-11 1972 VMT FOR LIGHT VEHICLES
CITY OF PHOENIX ONLY

Age (years)	(1) Per Cent of Vehicles in Use	(2) Relative Annual Mileage	(3) Weighted Fraction of Daily VMT	1972 VMT Autos (thousands)	1972 VMT Lt. Trucks (thousands)
0	6.03	3.8	.030	175	26
1	9.48	7.5	.095	558	81
2	10.10	11.4	.150	885	129
3	8.98	10.4	.121	718	104
4	8.46	9.5	.104	618	89
5	9.79	8.5	.103	609	88
6	9.15	7.8	.093	549	79
7	8.07	7.1	.075	441	64
8	7.27	6.4	.061	357	52
9	5.82	5.9	.045	266	38
10	3.86	5.5	.028	154	24
11	3.67	5.4	.026	152	22
12	2.47	5.4	.017	102	15
Over 12	7.35	5.4	.052	308	44
				5,892	855

$$(3) = \frac{(1) \times (2)}{\Sigma(1) \times (2)}$$

TABLE D-12 1977 VMT FOR LIGHT VEHICLES CITY OF PHOENIX ONLY

Age (years)	(1) Fraction of Vehicles in Use	(2) Relative Annual Mileage	(3) Weighted Fraction of Daily VMT	1977 VMT Autos (thousands)	1977 VMT Lt. Trucks (thousands)
0	.059	3.8	.029	209	30
1	.099	7.5	.096	684	100
2	.107	11.4	.156	1,123	162
3	.104	10.4	.138	998	144
4	.099	9.5	.120	866	124
5	.094	8.5	.102	740	108
6	.089	7.8	.089	644	93
7	.074	7.1	.068	688	71
8	.064	6.4	.052	377	54
9	.054	5.9	.041	296	43
10	.043	5.5	.031	222	32
11	.033	5.4	.023	163	24
12	.023	5.4	.016	118	17
Over 12	.058	5.4	.040	289	43
	1.000			7,217	1,045

$$(3) = \frac{(1) \times (2)}{\Sigma (1) \times (2)}$$

TABLE D-13 1972 AND 1977 HEAVY VEHICLE VMT
CITY OF PHOENIX ONLY

Age (years)	(1) Fraction of Vehicles in Use	(2) Relative Annual Mileage/Vehicle	(3) Weighted Fraction of Daily VMT	1972 VMT Heavy (thousands)	1977 VMT Heavy (thousands)
0	.034	3.6	.016	6	7
1	.071	7.6	.074	29	34
2	.100	11.6	.156	59	72
3	.095	10.9	.140	53	65
4	.089	10.2	.121	46	56
5	.080	9.4	.102	38	47
6	.070	8.5	.081	30	37
7	.062	7.7	.064	24	30
8	.053	6.9	.049	18	23
9	.038	6.2	.032	12	15
10	.037	5.3	.026	10	12
11	.033	4.6	.021	8	10
12	.032	3.8	.016	6	7
Over 12	.207	3.7	.102	38	47
	1.000		1.000	377	462

$$(3) = \frac{(1) \times (2)}{\Sigma (1) \times (2)}$$

TABLE D-14 SUMMARY OF VMT'S
CITY OF PHOENIX ONLY

Age (years)	1972 Daily VMT (thousands)			1977 Daily VMT (thousands)		
	Auto	Light Truck	Heavy Truck	Auto	Light Truck	Heavy Truck
0	175	26	6	209	30	7
1	558	81	29	684	100	34
2	885	129	59	1,123	162	72
3	718	104	53	998	144	65
4	618	89	46	866	124	56
5	609	88	38	740	108	47
6	549	79	30	644	93	37
7	441	64	24	488	71	30
8	357	52	18	377	54	23
9	266	38	12	298	43	15
10	154	24	10	222	32	12
11	152	22	8	153	24	10
12	102	15	6	118	17	7
Over 12	308	44	38	289	43	47
	5,892	855	377	7,217	1,045	462

Table D-15 presents current daily vehicle miles of travel by local jurisdictional areas within the Phoenix region. This data was utilized to generate the generalized relationship between vehicle travel density and distance from the Phoenix city center (location of the air quality monitoring station) which is indicated on Figure D-3. The figure indicates relatively low variation of vehicle travel density with distance from the CBD and little concentration at the city center. This is consistent with the highly dispersed pattern of land use, residential and employment activity in the region.

Figure D-4 indicates temporal distribution of daily vehicle travel by facility type for the Los Angeles area which was assumed to reasonably reflect temporal distribution in the Phoenix-Maricopa County region to the level of detail required for input to the air quality models.

TABLE D-15. VMT Data for Phoenix Jurisdictional Areas

Jurisdictional Area	Gross Area (Sq. Mi.)	VMT	VMT/ Sq. Mile	Direction From City Center	Distance From Dtwn P. (miles)
Avondale	2.5	22,000	8,800	W	16.0
Chandler	6.6	47,000	7,100	SE	16.8
Gilbert	1.0	6,000	7,000	SE	17.9
Glendale	16.8	331,000	19,700	W	8.8
Mesa	24.2	541,000	22,400	E	9.2
Paradise Valley	13.3	70,000	5,300	NE	9.4
Phoenix	248.0	6,959,900	28,100	C	0-5.0
Scottsdale	67.3	714,000	10,600	NE	9.2
Surprise	1.0	2,000	1,000	NW	19.6
Peoria	2.8	13,000	4,600	NW	13.2
Goodyear	0.9	500	600	W	16.5
Tempe	25.3	681,000	26,900	SE	8.0

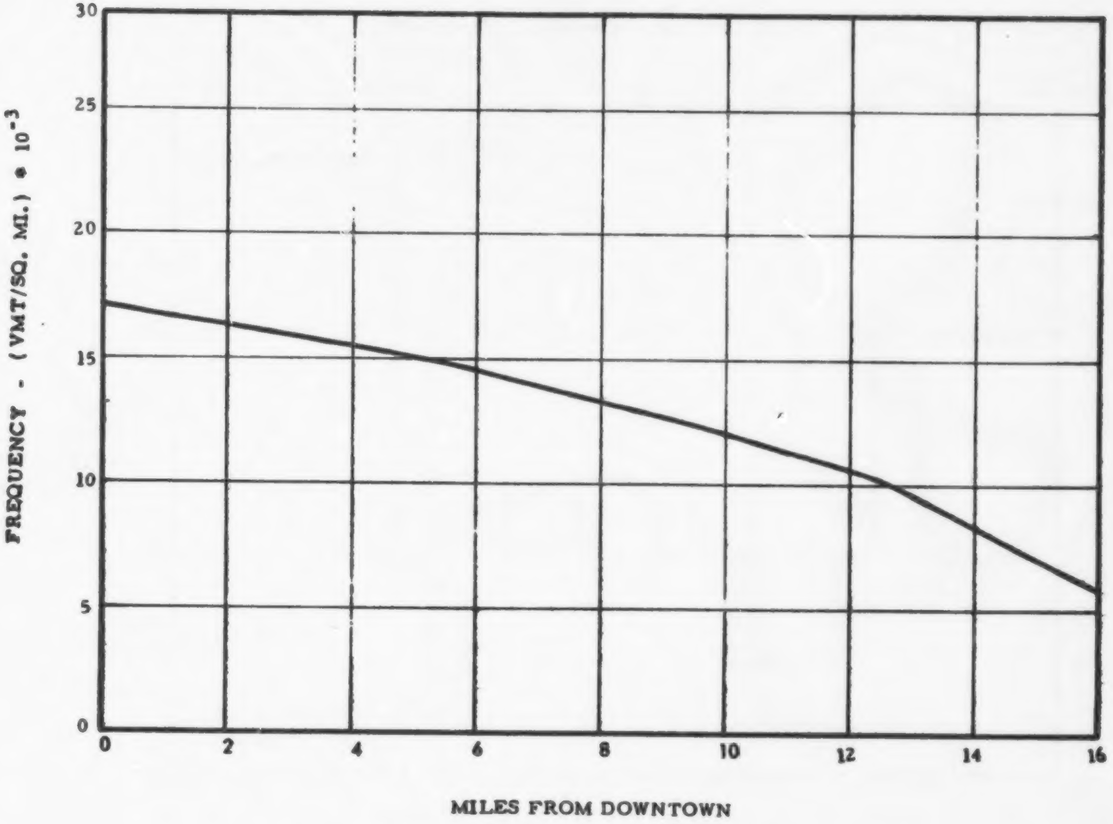


Figure D-3. Spatial Mileage Distribution for Phoenix

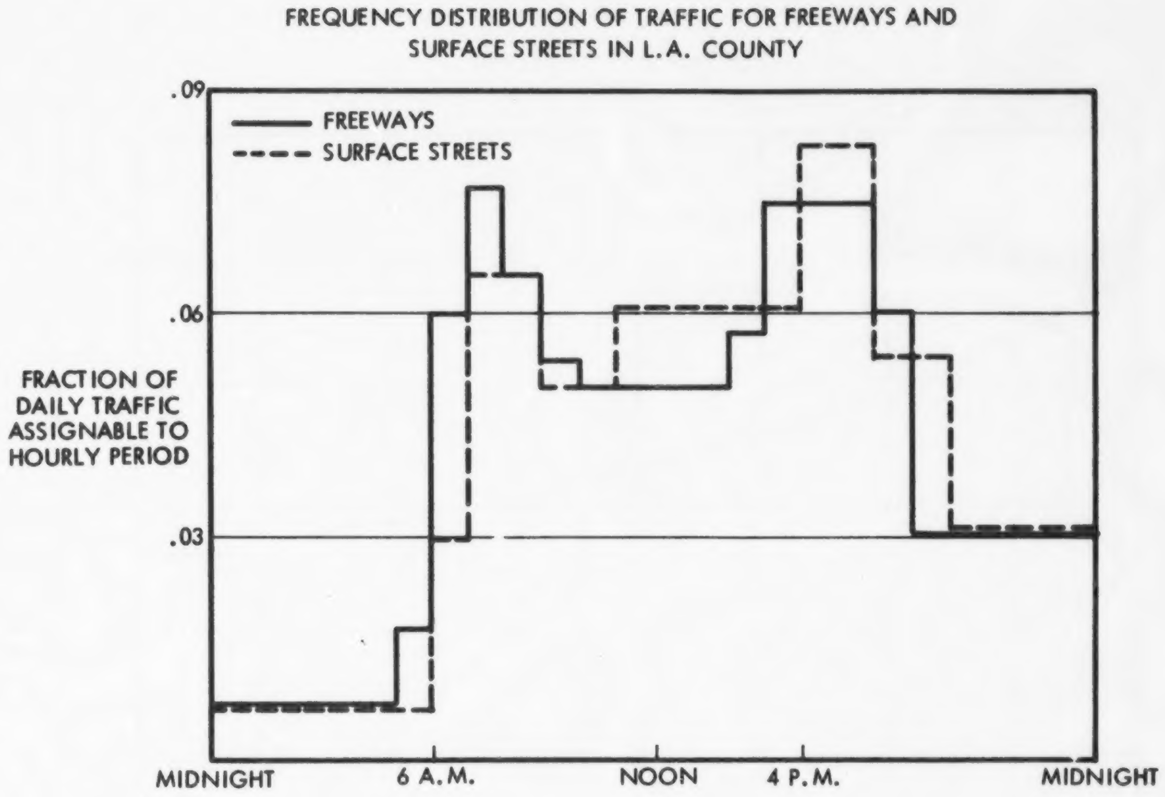


Figure D-4. Frequency Distribution

APPENDIX E

CONTACT REPORTS

Contact Report:	E-1
Subject:	Trip to Phoenix and Tucson by P. J. Weller
Date:	14-15 September 1972
Source of Information:	(See Text)

1.0 INTRODUCTION

Visits were made to Phoenix and Tucson government personnel to obtain base data on ambient pollution, pollutant emission, and transportation systems for the 14 Cities Project in the Phoenix - Tucson area. The following trip report describes who was contacted and summarizes general discussion with each. Published information obtained from these personnel is separate from this document.

2.0 PHOENIX AMBIENT DATA

2.1 Persons Contacted

Robert Taylor, Director, Bureau of Air Pollution Control, Maricopa County Health Department (MCHD), 1825 E. Roosevelt, Phoenix, Arizona 85006. James E. Layden, Bureau of Air Pollution Control, MCHD, 1825 East Roosevelt Phoenix, Arizona 85006.

2.2 Summary of Visit

At Taylor's office in the MCHD building I was introduced to Layden, who is responsible for ambient sampling. I toured the sampling facility in the building and observed analyzers and wind speed recorders in operation.

The worst Set II pollutant readings generally occur in winter during nightly inversions. These inversions begin at approximately 5 p.m. and last until morning, when the highest pollution levels are attained. Normally about 2 p.m., the inversion breaks. The summer pollutant concentration follows almost exactly the same daily cycle, except values are much lower. Maximum wind speeds in summer are 7 - 8 MPH, in winter 4 - 5 MPH.

The MCHD building is located a little southeast of the heart of town. However, according to Taylor, the correlation between downtown concentrations and readings at the MCHD building has been checked and found to be almost exactly 1:1, both in magnitude and periodicity.

I was shown data sheets for readings from 1969 through 1971, and arranged to have copies of these sent to me. Some sheets for 1970 and 1971 have not been completed; it was agreed that these would be completed in the necessary detail to be of utility to us before being sent (requires 1 - 2 weeks). Several cumulative and limit values are summarized at the bottom of each sheet, but no separate summary report for yearly data exists (other than the state I.P. for 1969).

3.0 PHOENIX EMISSION DATA

3.1 Persons Contacted

Arthur A. Aymar, Chief, Vehicular Emissions Control Section, Division of Air Pollution Control, Environmental Health Services, Arizona State Department of Health. Hayden Plaza West, 4019 North 33rd Avenue, Phoenix, Arizona 85017.

3.2 Summary Of Visit

I met with Aymar to discuss the state vehicle inspection data and facilities. According to Aymar, Ron Frey (same organization and address) is really the man to talk to in detail about the computer program used for data analysis and about the state vehicle emissions testing program. Unfortunately, Frey was out of town during my visit, so Aymar told me as much as he could.

Arizona obtained a mobile test unit for vehicle emissions testing in January 1970. Tests have been run in 1970 and 1971, using volunteered automobiles in public locations such as shopping centers and parking lots. Computer programs used for data analysis have been developed jointly by the states of Colorado and Arizona.

5000 vehicles have been tested in several modes of operation:

(1.) Dynamic Mode: Readings are taken at 50 MPH, 30 MPH, and idle for each car and then averaged (unlike the Clayton 3 - Mode Test, in which the three readings are analyzed separately.)

(2.) Idle Mode:
  (a) loaded - reading at RPM values representative of 50 MPH and 30 MPH.
  (b) unloaded - readings at RPM values representative of 50 MPH and 30 MPH.

Arizona is admittedly uncertain about whether their methodologies for both vehicle testing and data manipulation are correct. For example:

(1.) Should the three dynamic - mode readings be, indeed, averaged, should the readings be weighted differently, or should the three readings be analyzed separately?*

---

*Arizona emission standards are expressed as an average of the three readings.

(2.) Should the carburetor butterfly valves be kept at the same position or allowed to assume different positions (as in Arizona) during the idle mode test?

There is a program currently underway in which a preliminary design for state inspection stations is being developed by an architect and Automotive Environmental Systems, Inc. (AESI) of San Bernardino, California.

4.0 TUCSON ENVIRONMENTAL AND TRAFFIC DATA

4.1 Persons Contacted:

John Ensdorff, Director, Environmental Health Services, Pima County Health Department (PCHD), 151 West Congress, Tucson, Arizona 85701.

Clint Jarvis, air pollution engineering, PCHD, 151 West Congress, Tucson, Arizona 85701.

Chuck Rider, Tucson Area Transportation Planning Agency, 409 Lawyer's Title Bldg., Tucson, Arizona 85701.

4.2 Summary of Visit:

4.2.1 Environmental Data

After a few brief words with Ensdorff, I was introduced to Jarvis, who gave me several pieces of pertinent literature and discussed the Tucson situation. Very little ambient sampling data exists for Set II pollutants. According to both Ensdorff and Jarvis, the data that does exist is admittedly unreliable, due to possible equipment malfunction and the location of the samplers. Pollutant analyzers have been ordered by the PCHD and have recently been delivered.

The sources of Set II pollutants in Tucson are probably almost entirely related to the automobile, with a few exceptions:

(1.) An aluminum sweater southwest of town which is used to reclaim metal and alloy from aircraft frames and parts;

(2.) A copper smelter northwest of town;

(3.) The burning of natural gas as fuel in high-density areas such as hospitals, shopping centers, etc.

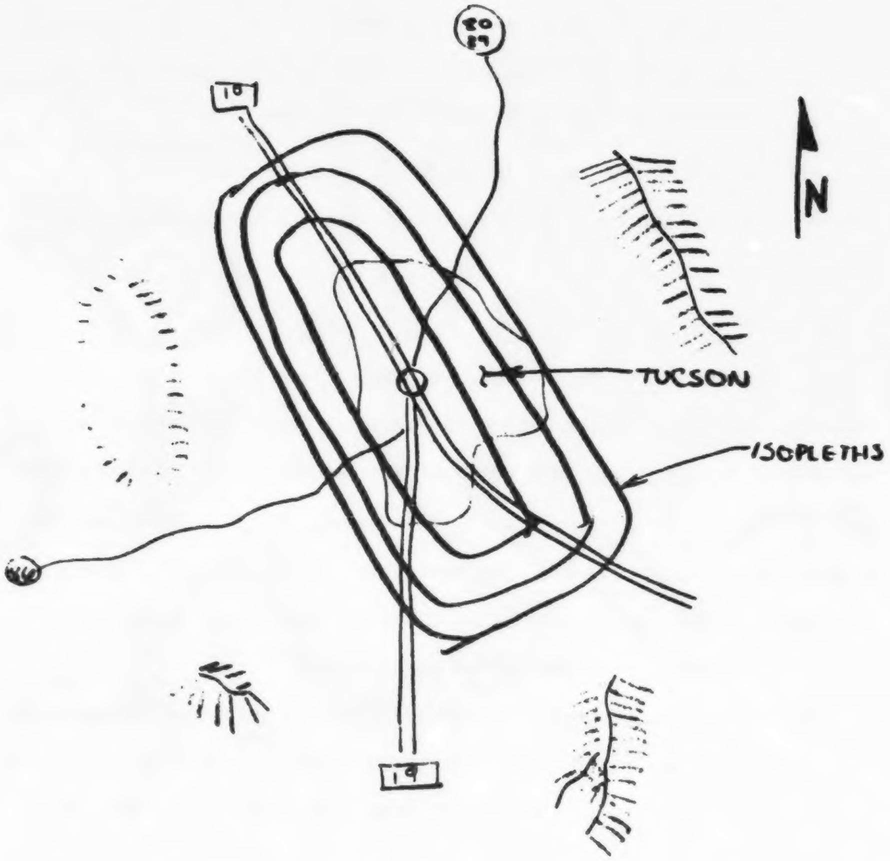
The characteristic shape of the Set I pollutant isopleths in Tucson is as in Figure E-1. It is expected that the Set II pollutants are similar.

4.2.2 Traffic Data

Jarvis introduced me to Rider for the transportation data. This data seemed to be complete with regard to forming a basis for control measure analysis. In fact, they have data which is probably much more detailed than we require (trip tables, turning frequency, etc.). Rider recommended however, that we not use the transportation systems data in a booklet I obtained from the Tucson City Clerk entitled "Air Pollution in Tucson" by the Tucson Advisory Committee on Air Pollution.

Tucson population growth is approximately 4% per annum at the present. The car population is, of course, growing more rapidly, and this seems to be one of the major bases for concern with regard to the air pollution problem.

Rider gave me several pieces of information and said he would send more involving projections, among other things. He will also send more detailed information, if requested.


80
89
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TUCSON
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86
19

Figure E-1. Set I pollutant isopleths in Tucson

Contact Report: E-2

Subject: Background Pollutant Concentrations in Phoenix

Date: 12 October 1972

Source of Information: Alan Raphael, Chemist, MCHD, Bureau of Air Pollution Control

1.0 INTRODUCTION

Mr. Raphael was contacted by phone by P. J. Weller to discuss background concentrations of HC, CO, O_x, and NO_2 in Phoenix.

2.0 INFORMATION GATHERED

2.1 HC

The background for total HC is approximately 2 ppm. However, the zero gas used in MCHD continuous analyzers has 2 to 4 ppm HC in it; therefore, the analyzers effectively subtract background from the total concentration readings.

2.2 O_x and NO_2

No background concentration data exists for O_x and NO_2. Zero gas is not used in the continuous analyzers.

2.3 CO

Background CO has not been quantified, but it is believed to be very low. Zero gas is used in the analyzer, but the concentration of CO in this gas is too low to be measured.

Contact Report: E-3
Subject: Trip to Phoenix by P. J. Weller
Date: 24-25 October 1972
Source of Information: (See Text)

1.0 INTRODUCTION

A trip was made by Peter J. Weller on 24 and 25 October 1972 to Phoenix, Arizona, as part of the TRW contract in the Fourteen Cities Program. The purposes of this visit were:

(1.) to gather information on stationary sources of pollutants and vehicle demographics

(2.) to present the Arizona State Health Department (ASHD) and Maricopa County Health Department (MCHD) a preview of the material TRW will present at the review meeting on 30 October 1972.

The following agencies and personnel are listed in the order in which they were contacted:

AGENCY	CONTACT
ASHD	Bruce Scott Division of Air Pollution Control (DAPC) Hayden Plaza West 4019 North 33rd Avenue Phoenix, Arizona 85017 (602) 271-5306
MCHD	Alan Raphael, Chemist Bureau of Air Pollution Control 1825 East Roosevelt Phoenix, Arizona 85006 (602) 258-6381

AGENCY	CONTACT
ASHD	Ron Frey DAPC (602) 271-5067
ASHD	Don Moon Staff Meteorologist DAPC (602) 271-5306
ASHD	Arthur Aymar Director DAPC (602) 271-5067
Arizona Public Service Co. (APS)	Ramon Fierroz (For Bill Kimsey) 411 North Central Phoenix, Arizona (602) 271-7900
Salt River Project (SRP)	Frank Scussel Director, Project Planning P.O. Box 1980 Phoenix, Arizona 85001 (602) 273-5402
SRP	Donald R. Squire Gen. Supt., Steam Generation P.O. Box 1980 Phoenix, Arizona 85001 (602) 273-2115
SRP	Jack A. Rassi Senior Environmental Analyst P.O. Box 1980 Phoenix, Arizona 85001 (602) 273-2503
Southern Pacific Pipelines, Inc. (SPPI)	L. L. Stamper Station Supervisor P.O. Box 14750 Phoenix, Arizona Business: 278-8564 Residence: 966-3087

2.0 BRUCE SCOTT, ASHD

2.1 Power Plants

According to Scott, all power plants in the Phoenix area will begin converting from natural gas to fuel oil within a year. The reason for this is the shortage of natural gas; California is pre-empting natural gas, and, besides, domestic use has a higher priority for natural gas than power production. The following are the chief operators of these power plants:

OPERATOR	CONTACT
Arizona Public Service	Bill Kimsey
Salt River Project	Frank Scussel

All these plants are essentially peaking plants; base load power comes mostly from Four Corners, Mohave, and other non-local plants.

2.2 Gasoline Evaporation

2.2.1 Filling Station Storage Tanks

A rule has been proposed in Arizona for the filling of gasoline storage tanks but was rejected by the Arizona Board of Health. This rule (see Attachment A) was very similar to Appendix B of the Federal Register of 14 August 1971. The estimated cost for each station to comply with this rule is approximately $15,000. The major objection to the rule was the fact that many ranches maintain gasoline storage tanks, and compliance would be an unreasonable financial burden. A similar rule, reworded to exclude ranchers from the requirements, would probably be accepted.

The laws of Arizona currently provide guidelines for submerged filling (see Arizona State Department of Health "Rules and Regulations for Air Pollution Control", Section 7.1.5).

2.2.2 Bulk Storage

There is a tank farm at 51st Avenue and West Van Buren. (The manager of this tank farm was subsequently contacted; see Section 8.0.)

2.3 Open Burning

Open burning is currently practiced at three dumps in the Phoenix area:

DUMP	OPERATION
Buckeye	Municipal
Tolleson	Municipal
Salt River Indian Reservation (SRIR)	Contract

It is unclear whether ASHD or MCHD has jurisdiction over the first two. The SRIR dump is 3 miles east of Scottsdale and about 15 miles east of Phoenix. The towns of Tempe, Mesa, and Scottsdale have disposal contracts with the dump operators and haul municipal waste there. These cities have land which can be used for landfill, but they have found that it is cheaper to contract with SRIR than to maintain their own landfills.

This dump was initially a landfill. When space ran out, the operators began burning the waste to allow more to be brought in.

Since Indian reservations are Federal (Dept. of Interior) lands, evidently neither ASHD or MCHD has authority to halt burning. At least one emotional confrontation has occurred, and the situation is a potentially sensitive one, although several solutions are in the offing. However, meetings with the landfill operators resulted in the development of a new landfill and the curtailment of burning at the old site.

2.4 Process Losses - Metallurgical Industries

These sources are typically scrap metal dealers and processors and are too small (less than 75 ton/day) to come under the jurisdiction of ASHD. The MCHD would have records on these.

2.5 Aircraft

In response to a question about whether the emission reduction shown for aircraft in the Arizona State Implementation Plan (ASIP) seemed reasonable, Scott stated a significant reduction is reasonable because of FAA retrofit regulations and new engine specifications. According to these, when an engine is serviced, it is retrofitted with a burner can which provides for leaner mixing and, therefore, lower particulate and CO emissions. This type of burner is a standard item on newer planes, such as the L1011, DC 10 and 747.

2.6 Emission Inventories

There are two recent inventories, in addition to the one done by Reta (St. Louis) for the ASIP: the 1969-1970 ASHD Inventory and the 1969 MCHD Inventory. The ASHD Inventory served as a basis for the corrected and improved ASIP inventory, and, therefore, does not provide better accuracy or more pertinent detail. The MCHD Inventory deals only with Maricopa County emissions, and could be a good source of information. It is being photocopied and sent by Scott.

2.7 Papago Freeway (Interstate 10 addition)

The plans for this freeway have been affected in two ways by different branches of EPA:

(1.) On the one hand, the ASIP has recognized that the freeway will have a beneficial effect on air quality by removing traffic from city streets and increasing average speed.

(2.) The impact statement issued by the Highway Department of the freeway was rejected by EPA, evidently because it did not deal with the entire planned freeway system, of which the Papago Freeway is only a part.

TRW recommendations emanating from this study will almost surely influence the acceptance of construction plans for this freeway.

2.8 Freeway Access Controls

Scott submitted a newspaper article describing a signal-controlled access sytem on the Black Canyon Freeway [6]

3.0 ALAN RAPHAEL, MCHD

3.1 Nonmethane HC Concentration

The MCHD estimate for nonmethane HC concentration as a percent of total hydrocarbon (minus background) is 10%. This estimate resulted from three days of testing which produced similar results (in the range 5% to 15%). There is no available test report which documents this estimate.

3.2 Maricopa County Sampling Locations and Capabilities

3.2.1 West Phoenix

This was a temporary station set up by the EPA in the summer of 1971 to measure the following:

- CO
- O_x
- Particulate
- Wind Speed
- Wind Direction
- Temperature
- Humidity

3.2.2 Paradise Valley

This is mobile lab data (see Section 3.2.5).

3.2.3 NASN

NASN samplers had been set up at MCHD on Roosevelt Avenue to test for NO_2 and O_x. Currently an NASN unit at MCHD is taking a 24-hour NO_2 sample every 12th day. Test results are used to compute an annual arithmetic mean. This analyzer is being operated by MCHD personnel.

3.2.4 MCHD Continuous Analyzers

MCHD uses Beckman analyzers with strip-chart recorders for continuous measurement of CO, NO_x, HC, and O_x. Wind speed, direction and incident solar radiation are also measured on a continuous basis in the MCHD building. Sensors and sample intakes are located on the roof of the building, approximately 35 feet from the ground. The reason samples are not taken nearer ground level is that MCHD wishes to avoid noise (superimposed short-period fluctuations) in the readout.

3.2.5 MCHD Mobile Lab

Mobile instrumentation is installed in an 18-ft. Clark-Cortez camper with a 110 volt refrigeration unit. The lab requires external power for refrigeration and instrument operation. Analyzers include:

- o Beckman NDIR for CO analysis
- o Beckman flame ionization unit for total HC
- o Salzman-type portable NO_x analyzer
- o Mast ozone meter for total oxidant

The mobile lab is scheduled for use at the corner of 19th Avenue and McDowell from 17 October 1972 to 13 November 1972 or longer to measure the effect of the Arizona State Fair while it is in town. CO, NO_x, and particulate will be measured.

3.3 Phoenix Inversion

Inversions occur every night in the winter, but never in the summer. Typically, they start one hour after sunset, begin lifting at approximately 8 a.m. and are completely broken up by noon or 1 p.m. Break up is largely due to the heat-up of the ground and is often coincident with an increase in wind speed.

4.0 RON FREY AND DON MOON, ASHD

4.1 Ambient Sampling

ASHD personnel are sampling CO and particulate and are gathering wind data at three locations in Phoenix. Samples are taken and analyzed every six days. Sixteen samples have been taken so far; it is expected that results will be issued on 1 December 1972.

HC concentration may be measured eventually in this effort. If so, it will be tested once a month with a Beckman analyzer.

4.2 Diffusion Modeling

ASHD plans to use the Air Quality Implementation Planning Program (IPP) developed by TRW to predict the influence of traffic on air quality. As a first step, IPP will be used to replicate the ambient data presently being gathered. The ultimate goal is to predict air quality a given distance from the freeway.

According to Moon, Phoenix experiences all six atmospheric stability classes (A, B, C, D, E and F - discussed in the Turner "Workbook for Atmospheric Dispersion Estimates" [2] in a 24-hour period.

5.0 ARTHUR AYMAR, ASHD

5.1 Vehicle Demographic Data

5.1.1 Incremental Odometer Reading

Arizona MVD does not have this data. Aymar suggested checking with an insurance company.

5.1.2 Scrappage Rate

Information unavailable.

5.2 Gasoline Storage and Distribution

5.2.1 Gasoline Distribution and Retail Sale

The following is a suggested information source:

Robert N. Harrison
Western Oil and Gas Association
609 South Grand Avenue
Los Angeles, California 90017
(213) 624-6386

5.2.2 Tank Farm in Phoenix

Suggested source:

L. L. Stamper, Station Supervisor
Southern Pacific Pipelines, Inc.
P.O. Box 14750
Phoenix, Arizona
Business: 278-8564
Residence: 966-3087

6.0 RAMON FIERROZ (FOR BILL KIMSEY) ASPC

6.1 Information Requested

Kimsey was out sick; Fierroz gave me as much information as he had and promised additional information, if available, by 30 October 1972, on:

(1.) the switch to fuel oil

(2.) pollutant emissions, as affected by the switch

(3.) plant street addresses

(4.) plant operating schedules

6.2 Information Received Immediately*

6.2.1 Ocotillo Power Plant (Tempe, Arizona)

- capability: both oil and gas combustion
- present fuel used: natural gas
- stack dimensions: 2 stacks, 8 1/2 ft. I.D., 170 ft. high

6.2.2 West Phoenix Plant (West Van Buren Avenue)

- stack dimensions:

  1 stack, 8 ft. I.D., 104 ft. high

  1 stack, 7 ft. I.D., 135 ft. high

  1 stack, 13 1/2 ft. I.D., 135 ft. high

NOTE: This is a standby plant; it is normally not operated in the winter and is smaller and older than the Ocotillo plant.

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* Better and more complete data is presented in Contact Report E-5.

6.2.3 Red Rock Plant

This plant is 60 miles from Phoenix.

7.0 FRANK SCUSSEL, DON SQUIRE, AND JACK RASSI: SRP*

7.1 General Description

Phoenix plants never exceed a load factor (on an annual basis) of 60%. Present natural gas use corresponds to 5 MM Bbl of oil per year (1971). In 1971 300 M Bbl of actual oil was used. Squire promised to mail a schedule for the planned fuel switch, providing management does not object to release of the information. In 1975, base load power for Phoenix will be entirely provided by the Four Corners and Mohave Plants; local plants will be used only for peaking. Phoenix experiences its greatest power demand in summer, because of air conditioning.

7.2 Specific Plants

7.2.1 Agua Fria

- location: 75th Avenue and Northern Avenue, between Peoria and Glendale
- generating units; 3 steam units

  2 - 100 megawatt
  1 - 65 megawatt
- fuel schedule: This plant will burn most of the oil.

  winter 1973 - 400 M Bbl/mo.
  summer 1973 - 100 M to 300 MBbl/mo.
- generating schedule:

  In summer; 10 a.m. to 10 p.m. - full load (100% LF)
  10 p.m. to 10 a.m. - 30% full load

  In winter; 8 a.m. - small peak

---

* Better and more complete data is presented in Contact Report E-6.

- Diesel Fuel (D2) Storage:

Current Tanks	1 - 110,000 Bbl, vented to atmosphere 1 - 131,000 Bbl, sealed
Probable Addition	1 - 200,000 Bbl, sealed

7.2.2 Kyrene

- location: 1 1/2 miles south of Baseline Rd. at Kyrene Rd.
- generating units: currently two steam units and two turbine units

Steam	1 - 33 megawatt 1 - 66 megawatt
Turbine	2 - 50 megawatt

There are plant to add two more turbines in 1973.

- schedule: Kyrene is almost always kept in reserve in both summer and winter.
- storage:

Current Tanks	1 - 10,000 Bbl, vented to atmosphere 1 - 23,000 Bbl, sealed 1 - 131,000 Bbl, sealed
Probable Addition	1 - 131,000 Bbl, sealed

7.3 Emissions

7.3.1 CO

CO emission is expected to be negligible.

7.3.2 HC

HC evaporation loss may result from filling of storage tanks. Otherwise, Reid vapor pressure is low with D2 fuels, and evaporative loss is not expected to be a problem.

7.3.3 NO_x

Scussel talked to the SRP Power Commission and received approval for a 6 to 8 month test on NO_x emissions. SRP Board approval is required, and it is expected. This will occur 6 November 1972. KVB Co. will perform tests. SRP intends to meet EPA NO_x emission regulations according to the 31 July 1973 schedule.

7.3.4 Additional Notes

(1.) SRP filed a report with ASHD describing expected emissions - report dated 8 October 1972.

(2.) SRP is using D2 diesel fuel, 1/2% sulfur, which more than meets standards for sulfur content.

7.4 Additional Information Expected by Mail

7.4.1 Schedule for fuel use (oil/gas) at both plants

7.4.2 Plant specification

7.4.3 8 October 1972 report to ASHD on expected emissions.

8.0 L.L. STAMPER, SOUTHERN PACIFIC PIPELINES, INC.

Oil companies own most of the tanks on the farm; SPPI owns only a few. Either floating roofs or cone-covered floating roofs are used on the tanks.

Stamper was at his home when I called him and much of the information I requested was unavailable. It was arranged that I call him the next day at his office on the tank farm so that he could provide me with the following:

- number of tanks vs roof type
- tank size vs roof type
- type of product vs roof type

Attachment A

Sec. 7.1.5 **Organic Compound Emissions from Stationary Sources***

Reg. 7.1.5.1 **Storage of Volatile Organic Compounds** -

A. No person shall place, store or hold in any reservoir, stationary tank, or other container having a capacity of 65,000 or more gallons any gasoline or any petroleum distillate having a vapor pressure of 2 pounds per square inch absolute or greater under actual storage conditions, unless such tank, reservoir, or other container is a pressure tank maintaining working pressure sufficient at all times to prevent hydrocarbon vapor or gas loss to the atmosphere, or is equipped with one of the following vapor loss control devices, properly installed, in good working order and in operation:

1. A floating roof consisting of a pontoon type of double-deck type roof resting on the surface of the liquid contents and equipped with a closure seal to close the space between the roof eave and tank well, a vapor baloon or vapor dome, designed in accordance with accepted standards of the petroleum industry. The control equipment shall not be used if the gasoline or petroleum distillate has a vapor pressure of 12 pounds per square inch absolute or greater under actual storage conditions. All tank gauging and sampling devices shall be gas-tight except when gauging or sampling is taking place.

2. Other equipment proven to be of equal efficiency for preventing discharge of hydrocarbon gases and vapors to the atmosphere.

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* Excerpted from Bill presented at Hearing before Board of Health.

B. Any other petroleum storage tank which is constructed or extensively remodeled on or after the effective date of these regulations shall be equipped with a submerged filling device or acceptable equivalent for the control of hydrocarbon emissions.

Reg. 7.1.5.2 Loading of Volatile Organic Compounds -

All facilities for dock loading of petroleum products, having a vapor pressure of 1.5 pounds per square inch absolute or greater at loading pressure, shall provide for submerged filling or acceptable equivalent for control of hydrocarbon emissions.
(The following part was struck in hearing: The loading facility shall be equipped with a loading arm with a vapor collection adaptor with pneumatic, hydraulic, or other mechanical means to force a vapor-tight seal between the adaptor and the hatch. A means shall be provided to prevent drainage of liquid organic compounds from the loading device when it is removed from the hatch of any tank, truck, or trailer, or to accomplish complete drainage before removal. When loading is effected through means other than hatches, all loading and vapor lines shall be equipped with fittings which make vapor-tight connections and which close automatically when disconnected.)

Contact Report: E-4

Subject: Tank Farm

Date: 26 October 1972

Source of Information: L. L. Stamper
Southern Pacific Pipelines, Inc.
P.O. Box 14750
Phoenix, Arizona
Business 602-278-8564

1.0 INTRODUCTION

Mr. Stamper was contacted by phone by P. J. Weller to discuss information concerning the operations and capacity of the tank farm operated by SPPI. Discussed were storage capacity, number of tanks, and throughput of the tank farm. Below is a summary of that telephone conversation.

2.0 INFORMATION GATHERED

2.1 Storage Capacity

Gasoline (including Aviation* Fuel):	750,000	Bbl
Total:	1,400,000	Bbl

2.2 Tanks

Floating roof:	gasoline	60
	turb. fuel	1
	JP4	2
	diesel	2
	Total	65
Cone roof: (3 being built)	Total	3

2.3 Throughput

Gasoline (3 grades + Aviation*)	1,400,000	Bbl/mo.
Current oil (including JP4)	400,000	
Oil increase expected	600,000	
Total throughput	2,000,000	Bbl/mo.

---

* Aviation gas is a very small per cent of total gasoline.

Contact Report: E-5

Subject: Arizona Public Service Company (APS) Power Plants in and near Phoenix; Description and Fuel Use.

Date: 1 November 1972

Source of Information: W. L. Kimsey, Manager
Environmental Consulting
Arizona Public Service Company

The following pages provide data on APS power plants in and near Phoenix. This data includes plant stack heights, locations, fuel descriptions, heat rates, and historic and projected fuel use.

ARIZONA PUBLIC SERVICE COMPANY
P O BOX 21666 PHOENIX, ARIZONA 85036

November 1, 1972

Mr. Pete Weller
TRW, Inc. E1-4048
1 Space Park
Redondo Beach, California 90278

Dear Mr. Weller:

You will find the attached information that you requested, concerning our Company's three generating plants located in the Phoenix-Tucson Intrastate Air Quality Control Region.

The (projected) fuel data on our gas turbine units is slightly different than that which I gave you over the phone.

Please let me know if we can be of further help to you on your project for the State Health Department.

Sincerely,

W. L. Kimsey, Manager
Environmental Consulting

WLK/b

Enclosures:

TABLE E-1. APS POWER PLANTS

I. Ocotillo

Location: Tempe, ARizona (Maricopa County)

Units: (Steam)

1 - 114.9 MW (Net generating capacity)
# 2 - 114.5 MW (Net generating capacity

Design Heat Rate:

10,420 btu/kwhr @ 110.7 MW

Stacks:

2 - 178' above ground level
8.5' I.D.

Max Gas Demand:

2300 mcf/hr.

Fuel Consumption:

	GAS	Oil
1970	8,183,205 mcf	—
1971	10,464,623 mcf	36,160 bbls.

Oil Storage:	Existing	Dec. '72	April '73
Fuel Oil (#6)	1-55,000 bbl.	1-100,000 bbl.	2-100,000 bbl.
Light Oil	1-21,000 gal.		
Diesel (#2)	1-30,000 bbl.		

Gas Turbine

1 - Westinghouse W-501-G 58 MW (Add 1 - 1973)

Stack Height - 50' above ground level

Heat Rate - 12,220 btu/kwh (base load)
11,930 btu/kwh (peak load)

TABLE E-1. (continued) APS POWER PLANTS

II. West Phoenix

Location: Phoenix, Arizona (Maricopa County)

Units: (Steam) - 3

Total Net generating capacity - 113.3 MW*

Design Heat Rate:

14,420 btu/kwh ; 14,100 btu/kwh ; and 12,180 btu/KWH

Stack:

104' - 8.0 I.D.

Max. Gas Demand:

1625 mcf/hr.

Fuel Consumption:

	Gas	Oil
1970	42,284 mcf	—
1971	398,667 mcf	—

Oil Storage:	Existing
Fuel Oil (#6)	55,000 bbl and 4,000 bbl.
Diesel (#2)	30,000 bbl.

Gas Turbine

1 - Westinghouse W-501-G 58 MW (Add 1-1973)

Stack Height - 50' above ground level

Heat Rate - Same as Ocotillo's

---

* 33.3 MW; 13.2 MW; and 66.8 MW

TABLE E-1. (continued) APS Power Plants

III. Saguaro

Location: Red Rock, Arizona (Pinal County)

Units: 2 (Steam)

Net Generating Capacity:

1 - 99.0 MW

# 2 - 99.0 MW

Design Heat Rate:

11,090 btu/kwh

Max. Gas Demand

2,100 mcf/hr.

Fuel Consumption:

	Gas	Oil
1970	2,748,933 mcf	—
1971	6,056,158 mcf	21,462 bbls.

Oil Storage	Existing	Dec.'72	June'73
Fuel Oil (#6)	55,000 bbl.	1-100,000 bbl.	1-100,000 bbl.
Diesel (#2)	30,000 bbl.	—	—

Gas Turbine

1 - Westinghouse W-501-G 58 MW (Add 1-1973)

Stack Height - 50' above ground level

Heat Rate - Same as Ocotillo's

TABLE E-2 APS STEAM GENERATING UNITS

(Projected Fuel Usage - Bbls of Oil & MCF[a] of Gas)

Year	Ocotillo		Saguaro		W. Phoenix		Yucca		Totals	
	Bbls	MCF	Bbls	MCF	Bbls	MCF	Bbls	MCF	Bbls	MCF
1972	154,170	10,918,555	80,755	5,719,240	9,790	693,245	13,885	2,657,330	258,860	19,988,370
1973	929,060	5,607,000	486,650	2,937,000	58,990	356,000	314,200	818,000	1,788,900	9,718,000
1974	1,828,830	1,427,490	957,600	747,730	116,480	90,635	375,600	750,000	3,278,510	3,015,855
1975	1,965,470	582,025	1,029,530	304,870	124,780	36,955	523,300	165,000	3,643,080	1,088,850
1976	1,787,095	--	932,800	--	116,765	--	600,900	--	3,437,560	--
1977	1,475,395	--	772,825	--	93,675	--	651,000	--	2,992,895	--
1978	1,226,920	--	642,670	--	77,905	--	651,000	--	2,598,495	--
1979	1,137,870	--	596,030	--	72,245	--	651,000	--	2,457,145	--
1980	1,105,870	--	579,265	--	70,210	--	651,000	--	2,406,345	--
1981	1,076,195	--	563,720	--	68,330	--	651,000	--	2,359,245	--
1982	944,765	--	494,880	--	59,985	--	651,000	--	2,150,630	--

[a] MCF = Thousand Cubic Feet

TABLE E-3. APS GAS TURBINE GENERATING UNITS
(Projected Fuel Usage - Bbls of Oil & MCF[a] of Gas)

Year	Ocotillo		Saguaro		Yucca		W. Phoenix		Douglas		Totals	
	Bbls	MCF	Bbls	MCF	Bbls	MCF	Bbls	MCF	Bbls	MCF	Bbls	MCF
1972	2,705	119,880	2,660	117,920	2,095	92,970	2,715	120,370	860	38,165	11,035	489,305
1973	14,735	695,195	14,435	681,065	13,475	635,850	14,795	698,020	2,450	115,870	59,890	2,826,000
1974	39,035	911,985	38,240	893,450	35,700	834,130	39,190	915,690	6,506	151,995	158,671	3,707,250
1975	241,950	110,700	237,035	108,450	221,295	101,250	242,935	111,150	40,323	18,450	983,538	450,000
1976	207,900	--	203,675	--	190,150	--	208,745	--	34,652	--	845,122	--
1977	148,895	--	146,355	--	136,185	--	149,500	--	24,339	--	605,274	--
1978	123,205	--	120,700	--	112,685	--	123,705	--	20,530	--	500,825	--
1979	122,480	--	119,990	--	112,025	--	122,975	--	20,412	--	497,882	--
1980	143,855	--	140,930	--	131,575	--	144,435	--	23,972	--	584,767	--
1981	154,495	--	151,355	--	141,305	--	155,125	--	25,749	--	628,029	--
1982	105,195	--	103,055	--	105,625	--	96,215	--	17,532	--	427,622	--

[a] MCF = Thousand Cubic Feet

Contact Report: E-6

Subject: Salt River Project (SRP) Power Plants in and near Phoenix; Description and Fuel Use

Date: 3-9 November 1972

Source of Information:
John O. Rich
Assistant General Manager
Power Operations
Salt River Project

The following pages provide data on SRP power plants in and near Phoenix. This data includes plant stack heights, locations, fuel descriptions, heat rates, and historic and projected fuel use.

SALT RIVER PROJECT
P. O. BOX 1980
PHOENIX, ARIZONA 85001
(602) 273-5900

KARL F. ABEL, PRESIDENT
JOHN R. LASSEN, VICE PRESIDENT
R. J. McMULLIN, GENERAL MANAGER

November 3, 1972

Mr. Pete Weller
TRW, Inc.
E1 4048
One Space Park
Redondo Beach, CA 90278

Dear Mr. Weller:

Attached is data you requested concerning SRP plants in the Phoenix area. In addition to the information on the attachments there are two gas turbines installed at Kyrene. The information concerning the gas turbines is penned in on the attachments. The gas turbines will be equipped with water injection to reduce NOx emissions therefore your studies might include NOx emissions from gas turbines similar to this that are installed in California.

The best information we can supply on fuel usage is that we expect to burn about three million barrels of diesel fuel in 1973. The Agua Fria Plant will generate 3060 millions of KWH's, Kyrene Steam 380 millions of KWH's and Kyrene Gas Turbine 260 millions of KWH's in 1973. It is not possible to present a more detailed breakdown at this time.

Fuel consumption in the Phoenix area plants for use in the foreseeable future is No. 2 diesel with a maximum sulfur content of 1/2 of 1%.

We hope this supplies the information you need in your studies for the EPA.

Very truly yours,

JOHN O. RICH
Assistant General Manager
Power Operations

sd
Attachments

STEAM-ELECTRIC PLANT AIR AND WATER QUALITY CONTROL DATA
PART I - AIR QUALITY CONTROL DATA

COMPANY NAME - SALT RIVER PROJECT

PLANT NAME - AGUA FRIA STEAM PLANT

COMPANY - PLANT CODE 433000-0100 | REPORT FOR YEAR ENDED - DECEMBER 31, 1969

SCHEDULE E - Equipment (Design Parameters) - Continued

Section 3 - Stack Data

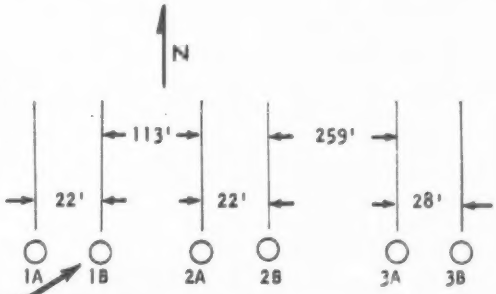
LINE NO.	(a)	STACK NUMBER (b)	STACK NUMBER (c)	STACK NUMBER (d)	STACK NUMBER (e)	CHECK FOR FOOTNOTE* (f)
	PLANT MW	99.0	99.0	165.0		
43	Stack Numbers	1A & 1B	2A & 2B	3A & 3B		
44	Installed Cost (Thousands of dollars) (Instruction 12, page 8)	72	81	111		X
45	Stack Height (Feet above Ground Elevation)	120	120	123		
46	Inside Diameter Of Flue at Top (Inches)	96	96	111		
	FLUE GAS RATE (CUBIC FEET/MINUTE)					
47	At 100% Load	29.85×10^4	29.85×10^4	46.66×10^4		
48	At 75% Load CAL	22.39×10^4	22.39×10^4	35.00×10^4		
49	At 50% Load CAL	14.93×10^4	14.93×10^4	23.33×10^4		
	EXIT GAS TEMPERATURE (DEGREES FARENHEIT)					
50	At 100% Load	300	300	242		
51	At 75% Load CAL	248	248	190		
52	At 50% Load CAL	220	220	170		
	EXIT GAS VELOCITY (FEET/SECOND)					
53	At 100% Load CAL	99	99	116		
54	At 75% Load CAL	74	74	87		
55	At 50% Load CAL	50	50	58		
56	Distance to next stack, Center to center (Feet)*	113	113	259		
57	Orientation of Line of Stacks - Degrees Clock-Wise From True North**	90° ⟶				

---

* All footnotes should be shown on Page 12.

** Show position of stacks by stack number to correspond with the identification in line 43. Enter true north on the diagram.

Stacks Orientation Diagram:



FLUE GAS CLEANING EQUIP. MANUFACTURERS (See pg. 10)

AAFC - American Air Filter Co., Inc.
AMST - American Standard, Inc.
BELC - Belco Pollution Control Corp.
BUEL - Buell Engineering Co., Inc.
DUCO - The Ducon Co., Inc.
FIKL - Fischer-Klosterman, Inc.
FULL - Fuller Co., Draco Products
KIRK - Kirk & Blum Manufacturing Co.
KOPP - Koppers Co., Inc.
PPCI - Precipitair Pollution Control Inc.
PAOA - Precipitation Associates of America, Inc.
PLVR - Pulverizing Machinery Division'
COTT - Research-Cottrell, Inc.
SVRS - Seversky Electronatom Corp.
UOP - UOP Air Correction Division
TORI - The Torit Corp.
WEST - Western Precipitation Division
WHEE - Wheelabrator Corp.
ZURN - Zurn Industries, Inc.
OTHE - Other (Specify in footnote)

TWO STACKS FOR EACH OF THE THREE BOILERS.

STEAM-ELECTRIC PLANT AIR AND WATER QUALITY CONTROL DATA
PART I - AIR QUALITY CONTROL DATA

COMPANY NAME - SALT RIVER PROJECT

PLANT NAME - KYRENE STEAM PLANT

COMPANY - PLANT CODE 433000 - 0600

REPORT FOR YEAR ENDED - D^CEMBER 31, 1969

SCHEDULE E - Equipment (Design Parameters) - Continued

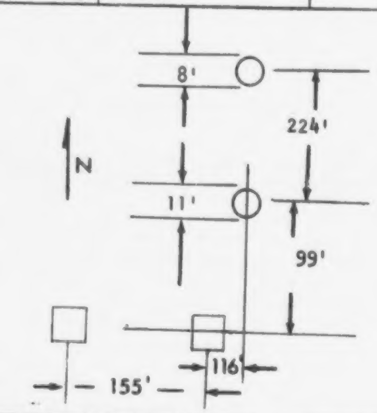
Section 3 - Stack Data

LINE NO.	PLANT MW (a)	33.0 STACK NUMBER (b)	66.0 STACK NUMBER (c)	57.0 (each) STACK NUMBER (d)	STACK NUMBER (e)	CHECK FOR FOOTNOTE (f)
43	Stack Numbers	1	2	3 & 4		
44	Installed Cost (Thousands of dollars) Instruction 12, page 8)	10.3	158.0	3		X
45	Stack Height (Feet above Ground Elevation)	75' 9"	120' 0"	37' 37'		
46	Inside Diameter of Flue at Top (Inches)	8' 0"	11' 0"	12'x21' 12'x21'		
	FLUE GAS RATE (CUBIC FEET/MINUTE)					
47	At 100% Load	142,306	248,811	554,000 SCFM(each)		
48	At 75% Load	106,730	186,608	-----		
49	At 50% Load	71,153	124,406	-----		
	EXIT GAS TEMPERATURE (DEGREES FARENHEIT)					
50	At 100% Load	350	320	850°F. (Nor. Full Load)		X
51	At 75% Load	280	275	-----		X
52	At 50% Load	260	240	-----		X
	EXIT GAS VELOCITY (FEET/SECOND)					
53	At 100% Load	47 Cal	43 Cal	102 fps		
54	At 75% Load	35.4 Cal	32.7 Cal	-----		
55	At 50% Load	23.6 Cal	21.8 Cal	-----		
56	Distance to next stack, Center to center (Feet)*	224	224			
57	Orientation of Line of Stacks - Degrees Clock-Wise From True North**	0	0			

* All footnotes should be shown on Page 12.

** Show position of stacks by stack number to correspond with the identification in line 43. Enter true north on the diagram.

Stacks Orientation Diagram:



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WEST - Western Precipitation Division
WHEE - Wheelabrator Corp.
ZURN - Zurn Industries Inc.
OTHE - Other (Specify in footnote)

SALT RIVER PROJECT
P. O. BOX 1980
PHOENIX, ARIZONA 85001
(602) 273-5900

KARL F. ABEL, PRESIDENT
JOHN R. LASSEN, VICE PRESIDENT
R. J. McMULLIN, GENERAL MANAGER

November 9, 1972

Mr. Pete Weller
TRW, Inc.
E1 4048
One Space Park
Redondo Beach, CA 90278

Dear Mr. Weller:

Additional history of SRP fuel usage is provided here per your verbal request.

ANNUAL FUEL CONSUMPTION OF SRP PLANTS

Year	Agua Fria		Kyrene		Cross Cut	
	Oil Bbls	Gas MCF	Oil Bbls	Gas MCF	Oil Bbls	Gas MCF
1969	16,483	18,770,000	854	2,160,000	0	0
1970	16,858	18,780,000	554	1,602,000	18	16,028
1971	175,131	18,235,000	19,923	3,102,000	1,478	14,197

The symbol Bbls represents 42 gallon barrels and MCF is thousands of cubic feet. The oil burned was mostly 0.9% sulfur residual.

Very truly yours,

JOHN O. RICH
Assistant General Manager
Power Operations

Contact Report: E-7

Subject: Open Burning Dumps

Date: 9 November 1972

Source of Information: Barry Abbott, Arizona State Department of Health, Division of Sanitation

1.0 INTRODUCTION

Mr. Abbott was contacted by telephone by P. J. Weller to obtain data on open burning dumps near Phoenix. The data included refuse tonnage and projected influences on emissions and was required for estimating emission rates in 1969 and future years. Dump sites at the Salt River Indian reservation, Tolleson, and Buckeye were discussed. In addition, Mr. Abbott stated that his office is developing a state solid waste plan which should include the elimination of open burning at dumps by 1975.

2.0 INFORMATION GATHERED

2.1 Salt River Indian Reservation

There is no data available for the base year, 1969. Tonnage estimates were based on 1970 census data and an assumption for per capita refuse production of 4 lb/person-day. The population figures are as follows for the towns hauling refuse to the dump:

Town	1970 Census Figure
Scottsdale Mesa	132,873
Tempe	63,550
Paradise Valley	7,155
Salt River Indian reservation	1,650

Projected 1975 populations are as follows:

Town	1975 Census Figure
Scottsdale	85,000
Mesa	83,000
Tempe*	---
Paradise Valley	9,000
Salt River Indian Reservation	2,500

Currently, 20 to 40% of the refuse tonnage is burnt. Less than this was burnt in 1979. No burning is expected in 1975.

2.2 Tolleson

The Tolleson dump is located three (3) miles south of the city of Tolleson. Very little (much less than 5% of the tonnage) is currently burned and 1969 data is unavailable. No burning is expected in 1975.

2.3 Buckeye

The Buckeye dump is located one (1) miles west of the city of Buckeye. In 1969 100% of the refuse tonnage was burnt. No burning is expected in 1975.

---

* Since 1972 Tempe has used its own dump rather than the Salt River Indian Reservation dump.

Contact Report: E -8

Subject: Trip Report on Gasoline Evaporative Loss Control Systems

Date: 10 November 1972

Source of Information: San Diego Air Pollution Control District

1.0 INTRODUCTION

1.1 Purpose

A trip to San Diego was made by Peter J. Weller on 8 October 1972 for the purpose of gathering information from the San Diego Air Pollution Control District (SDAPCD) on the control of hydrocarbon (HC) emissions from gasoline marketing.

1.2 Contacts

The following personnel were contacted:

Clark Gaulding, Deputy Air Pollution Control Officer
John Farnsworth, Senior Air Pollution Engineer
Barnard R. McEntre, Air Pollution Engineer
Ray Skoff, Air Pollution Engineer

All work at:

County of San Diego Air Pollution Control District
Department of Public Health
1600 Pacific Highway
San Diego, California 92101
(714) 236-3826

(McEntre and Skoff provided me with most of the information described in this report.)

2.0 TECHNICAL INFORMATION

2.1 General System Design

2.1.1 Baseline System

The baseline system is as follows: The tank truck fills an underground storage tank at the service station and car tanks are filled from pumps which bring gasoline from the underground tank. The disadvantages of this system are:

(1.) Since the temperature of the gasoline in the tank truck is very probably (in moderate to hot climates) higher than the gasoline temperature in the underground storage tank, the total vapor pressure in the underground tank is increased. Normally a 1.0 PSI relief valve is used for underground tanks, if the increase in vapor pressure exceeds this, gasoline vapor will be emitted to the atmosphere. (See Attachment A).

(2.) The empty car tank is similarly full of vapor, which is displaced to the atmosphere as the car tank is refilled.

(3.) The topcaps on the tank truck are opened during the transfer of gasoline to the underground tank. This allows air to enter the truck tank and gasoline vapor to exit from it. The air in the truck forms (according to McEntre) an explosive mixture* with the gasoline vapor in the truck. Thus, the driver returns to the bulk terminal with a highly dangerous cargo.

2.1.2 Recovery by Condensation

To recover vapor displaced from the underground tank (or car tank), some systems condense the vapor and either hold the condensate or return it to storage in the underground tank. Typically 10% of the hydrocarbon throughput is lost to the atmosphere with such a system.

---

* Minimum air-fuel ratio (weight basis) for explosive mixtures is 9: optimum (i.e., most effective for combustion) ratio for explosive mixtures is 14 to 16.

2.1.3 Recovery by Adsorption

Some systems use carbon canisters to adsorb the vapor. The canister may be periodically back-flushed (without removal) or may be removed and the trapped gasoline destroyed or recovered.

2.1.4 Recovery by Vapor-Return

With a vapor-return system, a vapor line running from the underground tank to the tank truck carries displaced vapor from the tank back to the truck. The truck is kept closed, except for the fill line and vapor line to the underground tank. When filling of the underground tank is complete, the truck returns to the bulk terminal with a load of saturated (and, therefore, non-explosive) gasoline vapor.

Vapor-return applied to car tank filling takes a similar form. A vapor line running parallel to the gasoline line used for filling car tanks returns displaced vapor to the storage tank. Both vapor-return applications require a vapor-tight coupling with each tank.

2.2 Specific Systems and Hardware

See Table E-4.

3.0 LEGAL AND POLITICAL INFORMATION

3.1 Rules 61 and 63

A package sent by Gaulding to gasoline marketing operators includes the applicable SDAPCD rules (61 and 63) and a compliance form for permitting. Key aspects of these rules are:

Rule 61: (1.) Lower tank size limit for control requirement is 250 gallons.

(2.) Last paragraph in (a) is subject to misinterpretation and should be more explicit.

Rule 63: (1.) Lower tank size limit for control requirement is 250 gallons for stationary tanks and 5 gallons for boat and MV tanks. (Average ranch or farm storage tank is 550 to 1000 gallons); filling station tanks range from 8000 to 10,000 gallons).

(2.) "All" in line 11, sentence beginning with "Loading.." is defined as 100% by SDAPCD.

(3.) Items (1) and (2) of the rule requires 90% efficiency for absorption and condensation and 100% efficiency ("all") for fuel handling (e.g., vapor return) systems.

(4.) Existing sources must have submitted a compliance schedule by 1 July 1972* and must be in compliance by 1 January 1974.

3.2 Legal and Political History

3.2.1 Suit by California Oil Jobbers Association

COJA supplies gasoline to private accounts and independent service stations. It filed a suit recently to challenge the rules but the suit has been dropped because COJA did not exhaust the administrative procedures specified in the rules (namely, the right of hearing and appeal.) A major contention is that COJA will be hurt economically by the new rules, but the organization has not been able to show an economic disadvantage.

---

*The date for this requirement has not been enforced rigorously - some schedules have been received, others are in progress.

3.2.2 Filling Stations

One station operator recently applied for authority to construct a station in San Diego. The application was initially rejected because of insufficient control, but the operator resubmitted the application, this time with a description of a recovery system. Action on this application has been delayed pending the development of tank farm facilities for disposal of vapor recovered from vapor-return systems at filling stations.

4.0 RECOMMENDATIONS

4.1 Contact suppliers of recovery systems and hardware, obtain specifications and higher resolution on cost figures and status.

4.2 Using the SDAPCD Rules 61 and 63 as a pattern, propose similar rules for the study area. Re-evaluate and improve on the SDAPCD rules, specifically with regard to the key aspects described in Section 3.1 of the above.

Table E-4. SYSTEM SUPPLIERS AND SPECIFICATIONS

Supplier	Description	Approximate Capital Cost*	Status
Atlantic Engineering	Condenser. Condensate is returned to underground storage tank.	$5000	Available
Calgon Corp. (Pittsburgh Activated Carbon Div.)	Adsorber. Replaceable carbon canisters; OPW pump nozzles are used. System being tested at San Diego County Operational Center, where county vehicles are serviced. PAC has funded modification of the Center.	--	Developmental
Dover Corp. (OPW Div.)	Nozzle only. This is the only commercially available nozzle at present.	$65 (Price will probably be reduced to $35 if/when nozzles are produced in large quantities)	Available
Ocean Resources, Inc.	Definition of system is presently vague.	Not determined	Unknown
Shields, Harper	Technical description has not yet been disclosed. Shields, Harper & Co. will own and lease out their recovery equipment. They will also own all gasoline recovered.	--	Developmental
Vaporex	System reduces the volume of entrained air mixed with vapor and returns recovered gasoline to storage tank. (Major restraint on this type system is that recovered gasoline must be at same temperature as gasoline in storage tanks.) A prototype is being used by Chula Vista Yellow Cab Co.	$1500	Prototype available
Russell, Birdsall & Ward (RBW)	Adsorber. Parallel carbon canisters. One canister is heated and backflushed by vacuum to the storage tank while the other remains in operation. Recovered vapor is bubbled thru liquid gasoline in storage tank. System includes a nozzle design (see Fig. 4).	$2300	Developmental

* Does not include installation and peripheral hardware (piping, valves, etc.) These estimated costs are volatile.

ATTACHMENT A

Estimates of Pressure Increase in Underground Storage Tank During Filling

Estimate (considered conservative):

Temperature of gasoline in truck = 90°F
Temperature of gasoline storage tank = 70°F

Assume:

2000 gal. gasoline in truck
400 gal. gasoline initially in storage tank

Thus:

Temperature of mixture after filling = 87°F

Initial tank pressure (before filling):

gasoline vapor:	6.8 PSIA
tank air:	7.9
total:	14.7 PSIA

Reproduced from best available copy.

Tank pressure after filling:

gasoline vapor:	9.4 PSIA
tank air:	7.9
total:	17.3 PSIA

Increase in vapor pressure = 17.3 - 14.7 = 2.6 PSIA

Contact Report: E-9

Subject: Reduction of Gasoline Reid Vapor Pressure

Date: 14 November 1972

Source of Information: Edwin E. Nelson
General Motors Corp.
Environmental Activities Staff
Warren, Michigan
(313) 575-1259

Mr. Nelson was asked whether lowering the Reid Vapor Pressure (RVP) of gasoline would conflict with Detroit requirements (or requests) for 1975 vintage vehicles, i.e., that higher fuel volatility will be required for efficient mixing with air. He answered that these two fuel properties are not necessarily mutually exclusive, as illustrated in Figure E-2.

The solid-line curve represents a typical fuel in use today. (Gasoline distillation curves vary with brand, geographic area, and season.) The dashed curve represents a possible fuel which has both properties. It has lower volatility at temperatures between ambient and carburetor temperatures (area ① of the graph), yet it has higher volatility at cylinder operating temperatures (area ②). Thus, RVP* can be reduced with no adverse effects on driveability for all cars through model year 1975 and after.

Gasoline manufacturers, however, will not be eager to alter fuel volatility beyond the range in which they are currently able to vary it (because of geographic and seasonal variation) for the following reasons:

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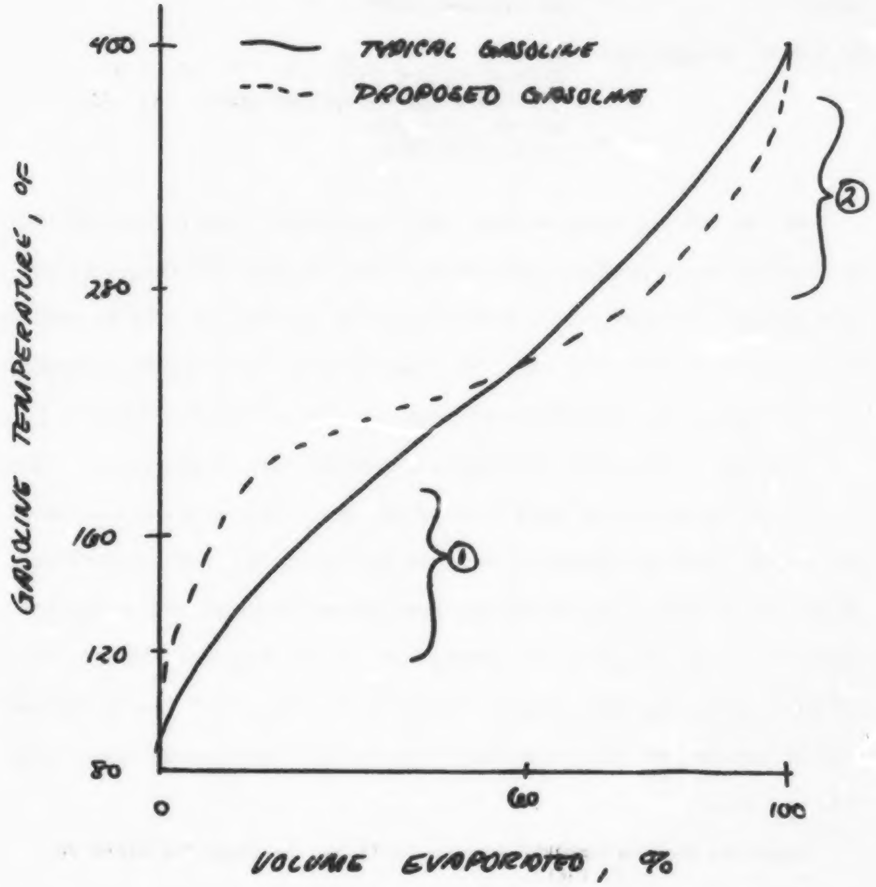
*RVP for a fuel is specified at a fuel temperature of 100°F.

Figure E-2. GASOLINE DISTILLATION CURVES



(1.) Such an alteration may mean capital expenditure for process modification.

(2.) Propane, butane, and other "light end" components of gasoline must be added in lower quantities in the refining process (to reduce RVP*).

This will reduce the gasoline output per barrel of crude and will have a detrimental effect on operating economics.

---

*Heavy ends must be removed at upper end of distillation curve tc increase volatility there.

CONTACT REPORTS

Contact Report:	E-10
Subject:	Phoenix Area Transportation Planning Data
Source of Information:	Mr. Tom Buick, Maricopa Association of Governments Transportation Planning Program (MAGTPP)

During the course of this project, Dan Smith of De Leuw, Cather and Co. had several meetings and telephone conversations with Mr. Tom Buick of MAGTPP, the regional agency responsible for coordinating ongoing transportation programs and continuing transportation planning in the Phoenix area.

MAGTPP served as a clearing house for information on ongoing and programmed improvement projects of all jurisdictions in the area as well as for transportation planning projection data. Much of the information contained in Appendix D as well as information on plans, programs and travel data utilized throughout this report has been furnished by MAGTPP with the consideration and assistance of Mr. Buick.

APPENDIX F

ORGANIZATIONS CONSULTED

American Petroleum Institute (API)
Arizona Automobile Association
Arizona Automobile Dealers Association
Arizona Association of Government
Arizona Public Service Company
Arizona State Commission of Agriculture and Horticulture
Arizona State Department of Health, Division of Sanitation
Arizona State Department of Public Safety
Arizona State Highway Department
Arizona State Inspector of Weights and Measures
Arizona State Tax Commission
Automobile Association of America (AAA)
Battelle Memorial Institute
California Air Resources Board
City of Phoenix Advance Transportation Planning Team
City of Phoenix Chamber of Commerce
City of Phoenix Traffic Engineering Department
Ethyl Corporation
First National Bank of Arizona
General Motors Corporation, Environmental Activities Staff
Maricopa Association of Governments Transportation Planning Program
Maricopa County Health Department, Bureau of Air Pollution Control
Maricopa County Highway Department
Motor Vehicle Manufacturers Association
Pima County Health Department

APPENDIX F (Continued)
ORGANIZATIONS CONSULTED

Salt River Project
Shell Oil Company
Standard Oil Company
Southern Pacific Pipelines, Inc.
Texaco
The Arizona Republic and Phoenix Gazette
Union Oil Company
Valley National Bank
Western Oil and Gas Association

APPENDIX G

AIR QUALITY MODEL

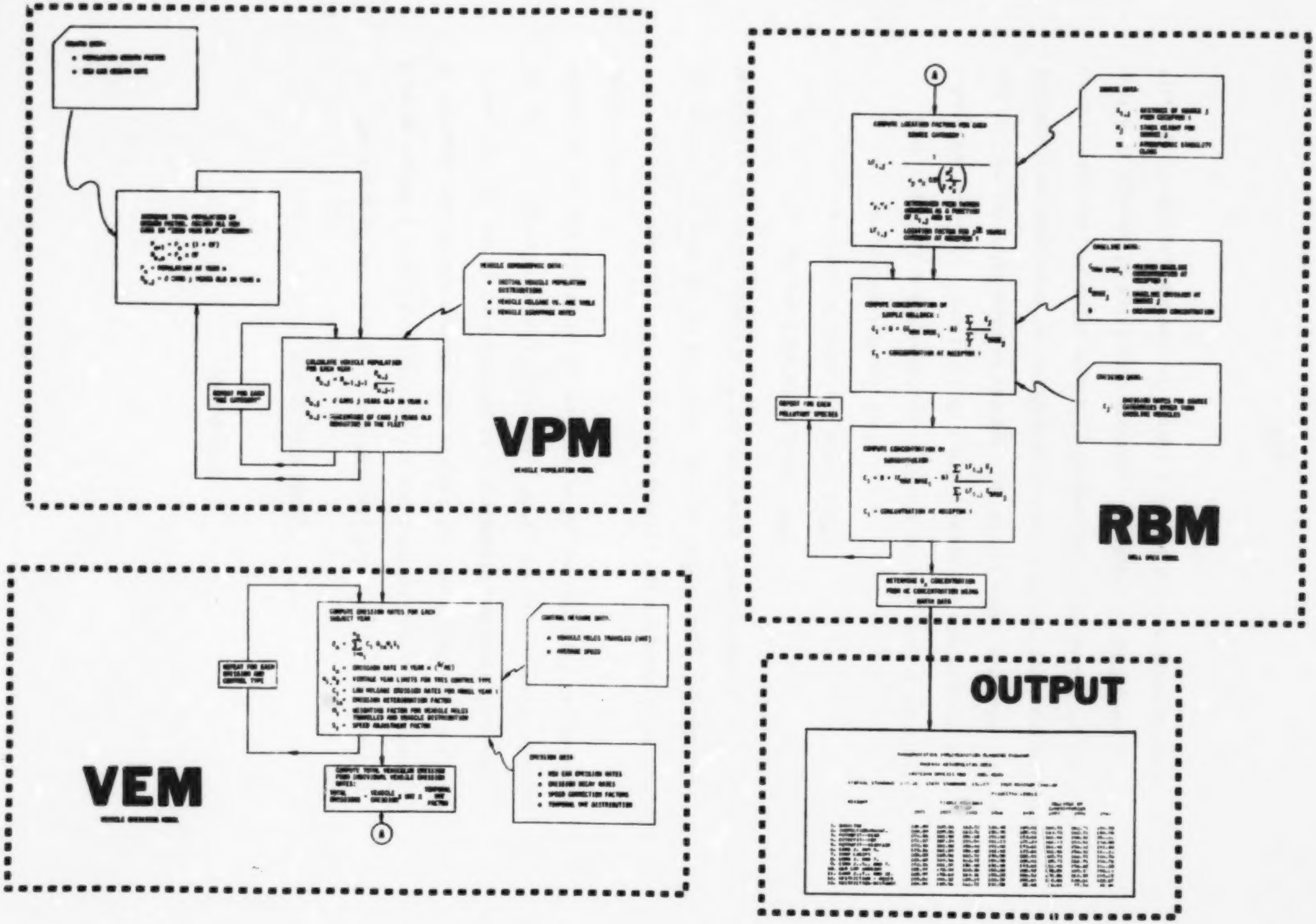
The state of air quality in our metropolitan area is influenced by a large number of complex relationships and interactions. Any attempt to forecast future air quality must account for these factors. One method for addressing this problem in a systematic framework involves the use of a computer simulation model. Here, the various relationships affecting air quality (such as transportation controls) can be assessed quantitatively.

The model developed for this study permits the forecasting of future air quality of each Set II pollutant for the 1975 through 1980 period. Basically, the model consists of the following three elements.

- Vehicle Population Model (VPM)
- Vehicle Emissions Model (VEM)
- Rollback Model (RBM)

Each describes a different facet in the process used to forecast future air quality. Figure G-1 presents a schematic overview of the composition and relationships between the various model elements. Since the model was developed for evaluating the merit of various transportation control measures, it quite naturally focuses with more detail on the mobile as opposed to stationary sources. The model is sufficiently flexible in design, however, to permit a more elaborate description of

Figure G-1. AIR QUALITY MODEL SCHEMATIC


VPM
VEM
REPEAT FOR EACH EMISSION AND CONTROL TYPE
COMPUTE EMISSION RATES FOR EACH SUBJECT YEAR
VEHICLE MILES TRAVELED (VMT)
AVERAGE SPEED
NEW CAR EMISSION RATES
EMISSION DECAY RATES
SPEED CORRECTION FACTORS
TEMPORAL VMT DISTRIBUTION
A
RBM
REPEAT FOR EACH POLLUTANT SPECIES
OUTPUT

stationary sources, as appropriate. The following presents a more detailed discussion of these three model elements and describes the methodology used for strategy assessment.

VEHICLE POPULATION MODEL

The Vehicle Population Model (VPM) is a general methodology for projecting future distributions of vehicle population versus vintage year. Used in conjunction with the Vehicle Emission Model, VPM can provide estimates of net emissions for the period 1975 - 1980 under a variety of alternate control measure considerations.

The basic model methodology involves analytically describing the "birth and death" process taking place within the vehicle population itself. Older vehicles are continually aging, with the oldest leaving the population entirely after many years of service. Simultaneously, new vehicles are being added to the population at some pre-assigned rate. Because of this process, the relative weights of various vehicle age groups in determining the net emissions change with time. Any accurate emissions projection must account for this phenomenon.

VPM computes the vehicle age distribution over time, adjusting for both new cars and vehicle attrition. This distribution provides a set of weighting factors for each age class and for each year analyzed. Combined with independently estimated vehicle emission rates, this distribution data can lead to emission projections weighted for changes in vehicle population characteristics.

This weighting process is crucial in making accurate projections. Under the current vehicle breakdown, three separate classes of light duty vehicles are considered: uncontrolled (pre-1968), controlled (1968 - 1970) and post 1970. Emission levels of the first two groups rise substantially over time due to vehicle deterioration. Yet, due to natural attrition processes, their numbers decline. The net contribution of these groups depends upon the interaction of both vehicle attrition and deterioration. Similarly, post-1970 vehicles have substantially reduced emission levels. (The emission levels for new cars are assumed to be in compliance with promulgated standards). As they enter the population and represent an increasingly large fraction, the aggregate emissions characteristics of the population will approach those of the post 1970 cars. It is this complex interaction between vehicle attrition, entrance of new cars and resultant population emission levels which is described quantitatively by VPM and which can provide a straightforward mechanism for projecting emission levels over future periods.

The model can also be used for measuring the time related effectiveness of various proposed vehicle control strategies, both singularly and in combination. This can be accomplished by introducing quantitative point estimates of strategy effectiveness and simulating the model over a specified time horizon.

VPM requires the following as basic input:

- Initial vehicle population
- Initial vehicle age distribution
- Population growth rate
- Vehicle attrition rates

VEHICLE EMISSION MODEL

The Vehicle Emissions Model (VEM) characterizes emission levels for the first five source categories of Table G-1. Equation G-1 presents the relationship used in estimating emission levels for categories one through four.

$$E = \sum_{i = n_1}^{n_2} Ci\ di\ Mi\ Si\ VMT \qquad (G-1)$$

where:

Ci = the new car (low mileage) emission rate for model year i

di = the time decay factor

Mi = the weighing factor for fraction of vehicle miles traveled

Si = the speed correction factor

VMTi = annual vehicle miles traveled per year for one vehicle in ith model year

n_1, n_2 = time limits for the appropriate category

E = emission rate by vehicle in grams per year

Similarly, equation G-2 shows the relationship for estimating evaporative and crankcase losses.

$$E = \sum hi\ Mi\ VMTi \qquad (G-2)$$

where:

hi = evaporative and crankcase emission rate for ith model year ır

Conversion of emission rates from grams per year to grams per second, for incorporation into RBM, requires the use of the diurnal distribution of vehicle miles traveled within the metropolitan area and *the pollutant

---

*See Appendix D

Table G-1. EMISSION SOURCE CATEGORIES FOR PHOENIX

1. Uncontrolled Vehicles
2. Controlled Vehicles
3. Post - 1970 Vehicles
4. Heavy-Duty Vehicles
5. Crankcase and Evaporative Losses
6. Filling Stations
7. Diesel Vehicles
8. Metallurgical Processes
9. Industrial Processes
10. Aircraft
11. Bulk Fuel Terminal
12. Open Burning Dumps
13. Power Plants
14. Process Losses

measurement sample basis. Both are used to calibrate annual emission rates with actual traffic flows and peak pollutant levels. The effectiveness of various control measures for these five categories is then applied directly to the resultant emission rates.

ROLLBACK MODEL

Two different methods are used for estimating future air quality. The first one, termed Simple Rollback, assumes that regional air quality will improve in direct proportion to reductions in regional emissions. Future air quality in year x is estimated by Equation G-3.

$$AQ_{\text{year } x} = b + (AQ_{\text{base year}} - b) \cdot \frac{\sum E_{\text{year } x}}{\sum E_{\text{base year}}} \qquad \text{(G-3)}$$

where:

b = background pollutant concentration level
AQ = air quality in year indicated
E = emission rate in year indicated

This technique, although simple to use, has the following restrictions:

1) It does not account for the fact that some emission sources are closer than others to the receptor or problem area.

2) It does not consider differences in effective stack height of the various sources.

3) It ignores meteorological conditions.

The Modified Rollback or Semidiffusion Method takes into account some of these effects while retaining the simple form of the rollback equation. This modification to Simple Rollback is an attempt to characterize the atmospheric distribution of emissions while avoiding a full scale dispersion model. While applicable dispersion models are available they have not been applied to the Phoenix area planning.

The Semidiffusion Method assigns a relative importance to each source depending on its distance from the receptor (or hot spot), the prevailing atmospheric stability class, and, to a small degree, the effective stack height of the source. This relative importance index is called the Location Factor (lf), defined for a particular source j in equation (G-4).*

$$lf_j = \frac{1}{\sigma_y \sigma_z \exp\left(\frac{h_j^2}{2\sigma_z^2}\right)} \qquad (G-4)$$

where σ_y and σ_z are functions of the atmospheric stability class and the distance from source to receptor, and h_j is the effective stack height.

The rollback equation using the location factors becomes:

$$AQ_{\text{year } x} = b + (AQ_{\text{base year}} - b) \frac{\sum lf_j E_{j,\text{ year } x}}{\sum lf_j E_{j,\text{ base year}}} \qquad (G-5)$$

Since the location factors appear in both the numerator and denominator of the concentration multiplier, only the relative magnitude is important.

---

* It is assumed for simplicity that only one receptor is being considered. Multiple receptors require double subscripting.

σ_z and σ_y increase. The rate of increase depends on the atmospheric stability class.

The atmospheric stability class characterizes those meteorological conditions appropriate to the case being analyzed. As described in the Turner Workbook [2], the stability class quantifies the turbulent structure of the atmosphere around the area being considered. It depends mainly on the amount of incoming solar radiation, the cloud conditions and surface wind speed. The stability class ranges from A to F, A being the most unstable, F the most stable. Figures correlating σ_y and σ_z with the stability class along with a complete description of the technique are found in the Turner Workbook.

The RBM correlates oxidant concentrations to hydrocarbon values through carbon of the Barth [20] relationship. The model references the nonmethane hydrocarbon concentration to derive oxidant concentration values at each year for each strategy.

Table G-1 presents a list of the 14 source categories (both mobile and stationary) used in characterizing the semidiffusion model for the Phoenix Region. In general, when controls are applied to mobile sources which are relatively closer to the receptor then their stationary counterparts, the Semidiffusion Method will yield lower estimates of pollutant concentrations than Simple Rollback.

STRATEGY ASSESSMENT

A measure can be defined (in the model) in terms of: 1) the percentage drops of emission rates in each source category, 2) a change in average speed for light and/or heavy duty vehicles, 3) a VMT multiplying factor, or 4) the new average distances between the sources and the receptor.

These parameters are used to compute the aggregate vehicular emission rates used in the air quality estimation.

The percentage emissions drops are applied directly to the aggregate vehicular emission rates. Inspection/maintenance, as an example, affects only the average emission rates and, thus, can be defined with percentage drops--12 for HC, 10 for CO, and 0 for NO_x with no change in the VMT multiplying factor, speeds or average distances.

The average speeds are used to determine the multiplying factor, Si, in equation G-1. As speed increases, Si decreases in a monotonic but nonlinear fashion, but has no effect on either NO_x emissions or post 1974 vehicles. This parameter, along with the VMT multiplying factor, allows the analysis of road improvement and traffic control measures.

The VMT multiplying factor affects all gasoline powered vehicle emission rates in a similar manner. Using a value of 0.5 means half the base year mileage can be eliminated by this strategy, resulting in a 50% drop in mobile source emission rates. The VMT factor can also be used to quantify unusual changes in growth patterns.

Distance changes influence the location factors instead of the emission rates themselves. Therefore, a strategy which changes only distance from source to receptor (such as removing all cars from the central business district) will affect only the Semidiffusion Method results. In general, moving a source away from the receptor will decrease the pollutant concentration an amount dependent on the percentage emissions contributed by that source and the atmospheric stability class. Experience has indicated that the Semidiffusion Method will yield lower estimates of pollutant concentrations then the simple method when the following conditions exist: 1) Mobile sources are located closer than stationary, 2) Mobile sources constitute a large component of the total, and 3) Measures applied to mobile sources result in significant emission reductions.

Combination strategies can be considered by the model by combining the percentages of separate measures. In general, the analysis of measure interactions is made by the user and the total percentage emission reductions are inputted into the model.

APPENDIX H

PHOENIX ATTITUDE SURVEY

Presented on the pages which follow are results of a questionaire distributed to a small sample of households in the Phoenix area. The survey was conducted with the assistance of a professional market research group*which maintains standing panels of households in each major metropolitan area in the U.S., each panel representing a broad cross section of households in the given area. The following table indicates some characteristics of the Phoenix panel.

	Less than $4,000	$4,000-8,000	$ 8,000-10,000	$10,000-15,000	$15,000+	Total
#HH having Income	18	52	22	59	27	178
#HH having Auto Ownership	0-car	1-car	2-car	3+-car	--	
	7	74	75	20	--	176

Significant insights to public attitudes which can be gleaned from the survey are as follows:

- o Nearly 97 percent of the respondents feel that air pollution is a problem in the Phoenix area and 60 percent feel it is a serious or very serious problem, However, 100 percent of the respondents feel that air pollution is a problem nationwide and some 90 percent of them feel that is a serious or very serious problem. The inference is that Phoenix area residents perceive that they have a local air pollution problem, but perceive their air polltuion problem as being less severe than that of the nation as a whole. (See Question 10)
- o Phoenix residents are generally supportive to retrofit program for pre-1975 vehicles which would cost about $50 per vehicle. Some 70 percent of the respondents indicated they would support such a program and an additional 11 percent indicated they were not strongly opposed to such a program. If the retrofit to pre-1975 vehicles were to cost $200 per vehicle only some 33 percent would support it. Inference is that low cost retrofits would be highly acceptable but requirements for catalytic converters would not be highly palatable.

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* Consumer Mail Panels, Chicago, Illinois

- Reaction to all types of travel restrictive controls is generally negative. Among the restrictive controls, exclusive bus and car pool lanes followed by traffic and parking bans in the CBD were seen as most acceptable although, evaluated of themselves, only about 50 percent of the respondents found these acceptable. The exclusive lanes acceptance is attributed to the fact that this is perceived as having the least overall impact while acceptance of CBD restrictions stems from the fact that only a small percentage of the areas residents now drive there frequently. (See Question 4)
- Some 80 percent of the respondents favor an inspection/maintenance program. Another 10 percent are not strongly opposed to the program. The respondents indicated a charge of nearly $7.00 as a reasonable cost for the annual inspection, significantly above the actual estimated cost for the inspection program under consideration. Nearly 50 percent of the respondents feel the inspection should be conducted at state operated inspection centers. Some 32 percent feel it should be done at local service stations or garages. (See Question 3)
- Response to transit related questions generally reflects the current low utilization of the Phoenix Transit System. Reasons given as most important in determining reliance on automobile transportation are'the auto is more available' (reflecting limited area coveraged routes and lack of all day, 7 day per week transit operation), 'auto more flexible' (reflecting both the current system's high headways and the general reluctance to be tied to a transit schedule) and 'the auto is faster'. Factors seen as most important in encouraging use of public transportation are 'more frequent service' (reflecting current high headway operation), 'more convenient stops and stations' (a desire for more area coverage) and 'lower fares'. The res responses indicate that achievement of significant increases level of transit utilization requires a major capital and operating commitment to a more extensive and higher level of service thanmthat currently provided rather than cosmetic improvements such as cleaner buses, air conditioning, bus stop benches and shelters, security and the like. (See Question5)
- Some 42 percent of the respondents indicated interest in car pooling for work commute trips. Less than 5 percent of the respondents are already in car pools. However, 75 percent of the respondents indicated it would be difficult for them to organize new or join an existing car pool. (See Question 6)
- Some 68 percent of the respondents favor staggered work hours as a means of reducing traffic congestion. Only some 14 percent oppose this proposal iwth the remainder indifferent. (See Question 8)
- Only 15 percent of the respondents would consider disposal of one family car if better public transit services were provided. Another 13 percent indicated they might consider disposing an automobile.

AUTO AIR POLLUTION QUESTIONNAIRE

		☐ 13
		14-16 Open

1. All autos made in 1975 and thereafter will be equipped with emmision control devices to reduce air pollution. If in 1975 you owned a car built before that year, how would you feel about a law requiring you to put emission control equipment which might cost $200 on your car? ("X" BELOW)

2. How would you feel about this law if the cost was reduced by government subsidy to about $50? ("X" BELOW)

Feeling Toward Law:	1. Cost $200 (17)	2. Cost $50 (18)
Very much in favor of law . .	☐1 12.9	☐1 49.4
Somewhat in favor of law . . .	☐2 20.0	☐2 20.3
Somewhat against law	☐3 17.1	☐3 11.6
Very much against law	☐4 50.0	☐4 18.6
RESPONDENTS	140	172

3a. Even cars properly equipped with emmision control equipment might still pollute the air if the equipment was not properly maintained. How would you feel about a law requiring periodic inspection of the emission control system to assure that it was working properly? ("X" ONE ONLY)

Very much in favor of law	Somewhat in favor of law	Somewhat against law	Very much against law		
☐1 53.7	☐2 26.0	☐3 10.7	☐4 9.6	177 RESPONDENTS	19

3b. Assuming you had to have your car inspected at least once a year, what would you consider a reasonable cost for the inspection? (WRITE IN AMOUNT)

169 RESPONDENTS $ 6.89

0-AUTO $5.70
1-AUTO $6.98
2-AUTO $6.29
3-AUTO $7.96

20 ☐☐ 21

3c. Assuming you had to have your car inspected at least once a year, where do you think the inspection should be made? ("X" ONE ONLY)

At state-operated inspection centers . ☐1 49.7
At city-operated inspection centers . . ☐2 13.6
At local service stations or garages . ☐3 32.2
At some other place (Specify): 4.5 ☐4 — 22
177 RESPONDENTS

4a. Even if all autos were equipped with properly maintained emission control systems, some cities might still have auto air pollution problems due to the large number of cars either on the streets at the same time or concentrated in particular areas. Listed below are several possible ways to reduce pollution under one or both of these conditions. Please tell me how you feel about each of these proposals. ("X" ONE ON EACH LINE)

To Me This Plan Is:

Proposal:	Very Acceptable	Somewhat Acceptable	Neither Acceptable Nor Unacceptable	Somewhat Unacceptable	Very Unacceptable			
a. Gasoline rationing	0.6 ☐1	7.7 ☐2	7.7 ☐3	9.5 ☐4	74.5 ☐5	-1.49	(9)	23
b. Very high ($500) registration fee per auto.	1.2 ☐1	— ☐2	6.0 ☐3	4.2 ☐4	88.7 ☐5	-1.79	(10)	24
c. Very high ($500) registration fee per auto but only for the second, third, etc., auto.	6.5 ☐1	9.5 ☐2	4.2 ☐3	16.7 ☐4	63.1 ☐5	-1.20		25
d. Prohibit traffic and parking in central business districts	16.5 ☐1	30.0 ☐2	8.7 ☐3	19.2 ☐4	25.6 ☐5	-0.06	②	26
e. A tax on all day parking in central business districts . .	15.5 ☐1	20.7 ☐2	16.1 ☐3	11.5 ☐4	36.2 ☐5	-0.92		27
f. A tax on parking in central business districts regardless of whether a person parked only one hour or all day	5.5 ☐1	14.7 ☐2	16.5 ☐3	12.9 ☐4	50.6 ☐5	-0.89		28
g. Tolls on exit ramps of major freeways and expressways	2.9 ☐1	9.6 ☐2	10.4 ☐3	19.7 ☐4	57.2 ☐5	-1.18		29
h. Tolls on exit ramps of major freeways and expressways but only when traffic was heavy.	2.3 ☐1	8.1 ☐2	12.2 ☐3	19.8 ☐4	57.6 ☐5	-1.22		30
i. Restrictions on non-essential auto travel during times of high pollution by issuance of special license plates or vehicle stickers	10.5 ☐1	20.9 ☐2	14.5 ☐3	11.0 ☐4	43.0 ☐5	-0.95		31
j. Turn some existing lanes into "bus only" and "car pool only" lanes on major expressways and streets.	32.8 ☐1	27.0 ☐2	12.6 ☐3	8.6 ☐4	19.0 ☐5	0.46	①	32

4b. Which of the proposals listed above would be the most acceptable? (Give Letter:) J 44.5 D 24.4 — 164 RESPONDENTS ☐ 33

4c. Which would be most unacceptable? . . . . (Give Letter:) B 54.7 A 33.1 — 172 RESPONDENTS ☐ 34

PHOENIX

QUESTIONS 5-8 ASK FOR INFORMATION RELATING TO OTHER HOUSEHOLD MEMBERS. CONSULT THEM, IF NECESSARY, FOR THE ANSWERS.

5a. How often do the various members of your household travel by public transportation? (For example, by bus, subway, or commuter train.)

	Husband		Wife		Children (Over 16 Years Old)	
Three or more times a week	—	☐1	1.7	☐1	1.0	☐1
One or two times a week	1.2	☐2	2.9	☐2	—	☐2
Once a month	1.9	☐3 (35)	2.3	☐3 (36)	—	☐3 (37)
Once every three months	0.4	☐4	4.6	☐4	2.0	☐4
Never	87.7	☐5	88.6	☐5	59.4	☐5
No household member	8.6	☐6	—	☐6	37.6	☐6
RESPONDENTS	162		175		101	

5b. Please rate each household member's reason for using public transportation. (Rate the most important reason "1", the next most important "2", the next "3", etc. If a household member never uses public transportation, "X" the "never use" box at the bottom of the list.)

5c. Please rate each household member's reasons for traveling by auto. Follow the same procedure as in Question 5b. (WRITE IN BELOW UNDER 5c)

1, 2 or 3 important

Reasons:	5b. Public Transportation (MEAN)			5c. Auto Transportation (MEAN)		
	Husband	Wife	Children (Over 16 Years Old)	Husband	Wife	Children (Over 16 Years Old)
a. Cheaper	4.00 (38)	① 3.96 (39)	N/M (40)	5.55 (41)	5.28 (42)	4.17 (43)
b. Faster	4.00 (44)	③ 4.00 (45)	N/M (46)	③ 2.95 (47)	③ 2.62 (48)	③ 2.69 (49)
c. More comfortable	② 3.33 (50)	5.33 (51)	N/M (52)	4.54 (53)	4.57 (54)	4.67 (55)
d. Safer for passenger	7.00 (56)	③ 4.00 (57)	N/M (58)	6.28 (59)	6.12 (60)	6.33 (61)
e. Less congested	7.00 (62)	② 3.88 (63)	N/M (64)	5.94 (65)	5.95 (66)	5.25 (67)
f. More available	① 3.00 (68)	③ 4.00 (69)	N/M (70)	① 1.96 (71)	① 1.90 (72)	① 1.58 (73)
g. More flexible (I can come and go as I please)	5.50 (15)	4.17 (16)	N/M (17)	② 2.30 (18)	② 2.19 (19)	② 1.73 (20)
h. More relaxing (able to read while traveling)	6.30 (21)	4.85 (22)	N/M (23)	----- (Not Applicable) -----		
i. Need car during the day	----- (Not Applicable) -----			5.98 (24)	4.85 (25)	3.60 (26)
j. I do not have a driver's license	6.00 (27)	6.83 (28)	N/M (29)	----- (Not Applicable) -----		
k. Car is not available when I need it	③ 3.67 (30)	5.00 (31)	N/M (32)	----- (Not Applicable) -----		
l. Other (Specify): ____________	1.00 (33)	4.33 (34)	N/M (35)	1.89 (36)	3.22 (37)	N/M (38)
m. Never use ("X" Box)	☐1	☐2	☐3 (39)	☐1	☐2	☐3 (40)
	142/148	155/175	60/63	4/148	7/175	3/63

(74-78 open)

79 -1 80

Cd. 2

Dup. 1-14

54. Again, consulting other members of your household, please rate in order of effectiveness which items below you feel would be most effective in encouraging the use of public transporation. (Rate the most effective item a "1", the next most effective "2", the next "3", etc.)

(MEAN)

Items:	**Husband**	**Wife**	**Children (Over 16 Years Old)**	
Cleaner and newer vehicles	6.1 (41)	5.8 (42)	5.5 (43)	
Faster travel.	4.1 (44)	4.6 (45)	4.3 (46)	
Air-conditioned vehicles	5.4 (47)	5.3 (48)	4.6 (49)	
More frequent service.	① 2.0 (50)	① 2.3 (51)	① 1.7 (52)	
Lower fares	③ 4.0 (53)	③ 4.0 (54)	③ 3.4 (55)	
Parking facilities at stops or stations	5.5 (56)	5.3 (57)	6.6 (58)	
Shelters against bad weather at stops or stations	6.2 (59)	5.5 (60)	6.1 (61)	
Better security to assure personal safety.	6.2 (62)	6.1 (63)	6.3 (64)	
More conveniently located stops or stations	② 3.0 (65)	② 2.9 (66)	② 3.2 (67)	
Other (Specify): ______	1.7 (68)	2.3 (69)	1.3 (70)	(71-78 open) 79 -2 80

6a. How would you or other household members feel about traveling to and from work in a car pool? ("X" ONE ONLY) Cd. 3

Dup. 1-14

		%	
Very interested	☐1	16.9	
Somewhat interested....	☐2	25.0	
Not at all interested	☐3	38.4	
Already in car pool.	☐4	4.7	15
Do not travel to and from work by car.	☐5	15.1	
RESPONDENTS		172	

6b. If it became necessary to restrict the number of cars on expressways and streets in order to reduce pollution and car pools became necessary, how difficult do you think it would be to get into one an existing one or organize one amongst your friends, neighbors and/or work associates. ("X" ONE ONLY)

		%	
Extremely difficult.....	☐1	30.3	
Very difficult	☐2	18.8	
Somewhat difficult	☐3	25.5	16
Somewhat easy	☐4	14.5	
Very easy..........	☐5	4.8	
Extremely easy	☐6	1.2	
Already in car pool	☐7	4.8	
RESPONDENTS		165	

7. One of the major causes of areas of high pollution is traffic congestion. Pollution could be reduced if traffic congestion and stop-and-go traffic was reduced. Listed below are several ideas for reducing traffic congestion. Please tell me how effective you think each of these ideas would be in reducing congestion and pollution. ("X" ONE BOX FOR EACH IDEA)

Idea:	Very Effective	Somewhat Effective	Not Effective At All	Would Increase Congestion	(MEAN)	
a. Prohibit parking, loading and unloading on busy streets	50.2 ☐1	39.7 ☐2	7.7 ☐3	2.4 ☐4	1.38	17
b. Increase the number of one-way streets..........	41.7 ☐1	42.5 ☐2	11.2 ☐3	4.4 ☐4	1.22	18
c. Establish reversible lanes on busy streets to be used during rush hours..........	33.7 ☐1	44.2 ☐2	12.6 ☐3	9.5 ☐4	1.01	19
d. Prohibit turns at busy intersections during rush hours .	53.3 ☐1	35.2 ☐2	6.5 ☐3	5.5 ☐4	1.38	20
e. Widen major streets..........	57.7 ☐1	31.4 ☐2	7.2 ☐3	3.7 ☐4	1.42	21
f. Widen major streets at intersections only..........	14.5 ☐1	47.6 ☐2	25.1 ☐3	12.6 ☐4	0.64	22
g. Provide pedestrian underpasses and/or overpasses ...	40.1 ☐1	37.0 ☐2	21.6 ☐3	1.4 ☐4	1.16	23
h. Improve timing of traffic signals..........	54.2 ☐1	39.5 ☐2	4.8 ☐3	1.2 ☐4	1.47	24
i. Increase the number and frequency of radio traffic reports	14.5 ☐1	53.7 ☐2	27.7 ☐3	3.6 ☐4	0.79	25
j. Turn some existing lanes into "bus only" and "car pool only" lanes on expressways and busy streets	32.7 ☐1	40.1 ☐2	19.5 ☐3	7.7 ☐4	0.97	26
Your ideas (Please List): ______ ______	75.5 ☐1	24.5 ☐2	- ☐3	- ☐4	1.76	27

8. Since traffic congestion is most severe at times when people are going to or coming from work, one alternative for reducing congestion would be to have people start and stop work at different times of the day. That is, some people would start work at 5:00 AM and quit at 2:00 PM, others would work from 7:00 AM to 4:00 PM, others from 10:00 AM to 7:00 PM, etc. How do you feel about this idea? ("X" ONE ONLY)

Very much in favor.....	☐1	36.9	
Somewhat in favor	☐2	31.3	
Indifferent............	☐3	17.6	28
Somewhat opposed	☐4	8.5	
Very much opposed.....	☐5	5.7	
RESPONDENTS		176	

9a. Please record the model year of each car owned in your household. (WRITE IN BELOW UNDER 9a)

9b. Please estimate the number of miles each car was driven in the last year. (WRITE IN NUMBER OF MILES UNDER 9b BELOW)

9c. For each car, please estimate what percentage of last year's mileage was accounted for by driving outside your local metropolitan area. (For example, vacation, business trips, short weekend trips, etc.) (WRITE IN BELOW UNDER 9c)

	9a. Model Year	9b. Last Year's Mileage	9c. Percentage of Mileage Outside Local Area	
Car #1	1968	11722	23 %	29 ☐☐☐ 31
Car #2	1967	8141	19 %	32 ☐☐☐ 34
Car #3	1966	6794	6 %	35 ☐☐☐ 37
Car #4	1965	3125	2 %	38 ☐☐☐ 40

9d. How many licensed drivers are there in your household? (WRITE IN)

Number of Licensed Drivers: 1.97 ☐ 41

9e. If better public transportation were available, would you consider disposing of any of the cars you own?

Yes ☐1 15.2
Maybe ☐2 12.8
No ☐3 72.0

9f. How many? (WRITE IN) 1.12 cars 42 ☐☐ 43

10a. Overall, how serious a problem do you think auto air pollution is in your city? ("X" ONE BOX UNDER 10a BELOW)

10b. Overall, how serious a problem do you think auto air pollution is nationwide? ("X" ONE BOX UNDER 10b BELOW)

	10a. City		10b. Nationwide	
Very serious problem.	26. ☐1	(44)	56 ☐1	(45)
Serious problem	33. ☐2		33 ☐2	
Slightly serious problem	36. ☐3		10 ☐3	
No problem at all.	3. ☐4		— ☐4	
RESPONDENTS	176		168	

11. If you have any views or comments regarding any question or idea, please record them:

(46-78 open)
79 -3 80

Thank you for your help. Please check your answers and then return the questionnaire to me in the enclosed postage-paid envelope.

APPENDIX I

LIST OF REFERENCES

1. "Arizona Statistical Review," 26th Annual Edition, Economic Research Department, Valley National Bank, September 1970.

2. Turner, Bruce D., "Workbook of Atmospheric Dispersion Estimates," U.S. Department of Health, Education, and Welfare, Public Health Service, National Air Pollution Control Administration, No. PB191482, 1970.

3. "Control Techniques for Hydrocarbon and Organic Solvent Emissions from Stationary Sources," U. S. Department of Health, Education, and Welfare Public Health Service, Environmental Health Service, National Air Pollution Control Administration, Washington, D.C., March 1970.

4. "Control Techniques for Carbon Monoxide, Nitrogen Oxide, and Hydrocarbon Emissions from Mobile Sources," U.S. Department of Health, Education, and Welfare, Public Health Service, Environmental Health Service, National Air Pollution Control Administration, Washington, D.C., March 1970.

5. "Passenger Cars (MLS-4) Registration Counts by Make and Year of Model," Compiled from Official State Records by R. L. Polk & Co., July 1, 1971.

6. Schatt, Paul, "Car Flow to be Controlled on Freeway," The Arizona Republic newspaper, October 15, 1972, pp. 28-A.

7. Hendrickson, D. L., (Mobile Oil Corp.), S. D. Lawson, (Phillips Petroleum Co.), A. R. Cunningham, (Esso Research and Engineering Co.), J. Byrne, (Union Oil Co.), E. L. Winkler, (Rock Island Refining Corp.), "Effect of Changing Gas Volatility on Refining Costs," Chemical Engineering Progress (Vol. 65, No. 2), February 1969, pp. 51-58.

8. Kircher, David S., D. P. Armstrong, "An Interim Report on Motor Vehicle Emission Estimation," Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina, October 1972.

9. "Arizona Vehicular Emissions Computer Data Program Specification," to be published and incorporated as part of the Arizona-Colorado Cooperative Agreement.

10. Aymar, A. A., "Findings of the Vehicular Emissions Test Program," Arizona State Department of Health Vehicular Emissions Control Section, August 5, 1971.

11. "Air Pollution Motor Vehicle Emissions Inspection," Chapter 14, Article 2, State Department of Health, Phoenix, Arizona, No. 36-1751, 1972.

12. "Rules and Regulations," County of San Diego, Department of Public Health, Air Pollution Control District, Revised Edition, February 1972.

13. "Rules and Regulations," County of Los Angeles Air Pollution Control District.

14. "Phoenix Urban Area Public Transportation Study," De Leuw, Cather & Company.

15. "Rollback Modelling, Basic and Modified," Noel de Nevers, August 1972.

16. "Profile of Air Pollution Control," County of Los Angeles, Air Pollution Control District, 1971.

17. "Handbook of Chemistry and Physics," 44th Edition, The Chemical Rubber Co.

18. Maricopa County Air Pollution Source Inventory," 1969-1970 "Compilation of Air Pollutant Emission Factors," U.S. Environmental Protection Agency, Office of Air Programs, Research Triangle Park, North Carolina, February 1972.

19. "The State of Arizona Air Pollution Control Implementation Plan," May 1972.

20. "Relationship of Hydrocarbons to Oxidants in Ambient Atmospheres," National Air Pollution Control Administration, Environmental Health Service, Department of Health, Education, and Welfare, Volume 20, No. 5, May 1970, pp. 297-302.

21. "Enforcement Considerations Regarding Approvable Transportation Control Strategies," United States Environmental Protection Agency, Washington, D.C.

22. "Regulation 40 CFR Part 51, Protection of Environment: Requirements for Preparation, Adoption, and Submittal of Implementation Plan, Transportation Control Measures."

23. Nelson, Edwin E., "Hydrocarbon Control for Los Angeles by Reducing Gasoline Volatility," (S.A.E. Paper No. 690087) Detroit, Michigan, January 1968.

24. Cole, Edward N., "Progress Toward Achieving 1975 and 1976 Federal Emission Standards," (Remarks before the American Petroleium Institute) Pebble Beach, California, September 26, 1972.

25. "Air Quality Criteria for Hydrocarbons," U.S. Department of Health, Education, and Welfare, Public Health Service, Environmental Health Service, National Air Pollution Control Administration, Washington, D.C., March 1970.

26. "Air Quality Criteria for Nitrogen Oxides," Environmental Protection Agency, Air Pollution Control Office, Washington, D.C., January 1971.

27. DeLeuw, Cather and Company, "Phoenix Urban Area Public Transportation Study,"July 1971.

28. Arizona Republic and Phoenix Gazette, "Inside Phoenix 1972."

29. Maricopa Association of Governments Transportation Planning Program.

30. Advanced Transportation Planning Team, City of Phoenix, "Mobility, Phoenix Style," April 1969.

31. Valley Area Traffic and Transportation Study, "1966 Travel Time Survey," VAATS Report No. 7, September 1967.

32. "Statement on Cost of Changing Fuel Composition," Western Oil and Gas Association, November 10, 1969

33. "The Economic Effectiveness of Mandatory Engine Maintenance for Reducing Vehicle Exhaust Emissions," CRC Extended Phase I Study Year-End Report, January 1972.

34. "Gasoline Modification--Its Potential as an Air Pollution Control Measure in Los Angeles County," Final Report, California Air Resources Board, Los Angeles County APCD, Western Oil and Gas Association, November 1969.

35. Compilation of Air Pollution Emission Factors. U.S. Environmental Protection Agency, February 1972.

36. "The Composition of Fuels and Their Effect on Emissions from Motor Vehicles and Combustion Engines",Arizona State Department of Health, Division of Air Pollution Control, December 1970.

37. Jackson, Marvin W., and Everett, R.L., "Effect of Fuel Composition on Amount and Reactivity of Evaporative Emissions," (SAE Paper No. 69088) Detroit, Michigan, January 1969.

38. "Reactivities of Exhaust Emissions from Controlled and Uncontrolled Vehicles", California Department of Public Health, August 1966.

39. Hurn, R.W., Dimitriades,B., and Fleming, R.D., "Effect of Hydrocarbon Type on Reactivity of Exhaust Gases", Chicago, Illinois, May 1965.

40. "Air Quality Criteria for Photochemical Oxidants," U.S. Department of Health, Education, and Welfare, Public Health Service, National Air Pollution Control Administration, Washington, D.C., March 1970.